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## MODELS AND TECHNIQUES FOR EVALUATING THE EFFECTIVENESS OF AIRCRAFT COMPUTING SYSTEMS

## Semi-Annual Status Report Number 4

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John F. Meyer

THE UNIVERSITY OF MICHIGAN Ann Arbor, Michigan 48109

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Langley Research Center Hampton, Virginia 23665



MODELS AND TECHNIQUES FOR EVALUATING THE EFFECTIVENESS OF AIRCRAFT COMPUTING SYSTEMS Semi-Annual Status Report Number 4 Covering the Reporting Period

1 November 1977 - 31 May 1978

Prepared For National Aeronautics and Space Administration Langley Research Center Hampton, Virginia 23365 Sal J. Bavuso, NASA Technical Officer NASA Grant NSG 1306

John F. Meyer, Principal Investigator Department of Electrical and Computer Engineering Systems Engineering Laboratory SEL Report Number 120 The University of Michigan Ann Arbor, Michigan 48109

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#### 1. INTRODUCTION

This report is the fourth Semi-Annual Status Report on the research project "Models and Techniques for Evaluating the Effectiveness of Aircraft Computing Systems" being conducted for the NASA Langley Research Center under NASA Grant 1306. The subject grant was initiated 1 May 1976 for a one year period and extended 1 May 1977 for a second one year period. This report concerns work accomplished during the second half of the second year (which included a one month no-cost extension at the end of the year), that is, the period from 1 November 1977 to 31 May 1978, hereafter referred to as the reporting period.

The purpose of this research project is to develop models, measures, and techniques for evaluating the effectiveness of aircraft computing systems. By "effectiveness" in this -context we mean the extent to which the user, i.e., a commercial air carrier, may expect to benefit from the computational tasks accomplished by a computing system in the environment of an advanced commercial aircraft. Thus, the concept of effectiveness involves aspects of system performance, relaibility, and worth (value, benefit) which must be appropriately integrated in the process of evaluating system effectiveness. Specifically, the primary objectives cf this project are:

- The development of system models that can provide a basis for the formulation and evaluation of aircraft computer system effectiveness,
- (2) The formulation of quantitative measures of system effectiveness, and
- (3) The development of analytic and simulation techniques for evaluating the effectiveness of a proposed or existing aircraft computer.

Effort during the reporting period has also been devoted to the documentation of research results for dissemination at technical conferences and in the open literature. In particular, some definitive results of the first year's activity were submitted for presentation at the 8th International Symposium on Fault-Tolerant Computing (Toulouse, France, June 21-23, 1978). This paper was accepted and will appear in the Proceedings of FTCS-8 [4]. Another paper, based on the same work but stressing the unification of performance and reliability, has been accepted for presentation at the Symposium on Modelling and Simulation. Methodology (Rehovot, Israel, August 13-18, 1978). More recent results concerning "functional dependence" (R-dependence) and its implications (see [3] and Section 3.1 of this report) have been presented at the 1978 Johns Hopkins Conference on Information Sciences and Systems (Baltimore, Maryland, March 1-3, 1978) and will be published in the Proceedings of that conference [5]. In addition, a paper focusing on the "performability evaluation of fault-tolerant multiprocessors" in a commercial aircraft environment has been accepted for presentation at the 1978 Government Microcircuit Applications Conference (Monterey, California, November 14-16, 1978). Finally, a slightly expanded version of the FTCS-8 paper [4] has been submitted for publication in the IEEE Transactions on Computers.

Section 2 of this report describes the manpower effort proposed for the current year, the personnel involved in conducting the investigation, and their levels of effort during the reporting period. Section 3, the body of the report, describes

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the technical status of the research performed during the reporting period.

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3. TECHNICAL STATUS

The following is a comprehensive description of the research performed during the reporting period. The report is divided into three major sections under the headings:

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3.1 Functional Dependence,

3.2 Evaluation Algorithms and Programs (METAPHOR),

. สารณ์ที่ 6 - แต่น้ำสาราชการไก้การ ควากการ 2 และสิวทศาหรรมการสุม 2 6 RAD ลิต Performability Evaluation of the SIFT Computer 3.3 wipara a hersterre . Alle is indress i lensarer (1) Section 3.1 describes our further investigation of the labor v addill v vitulaas vidigia aronal lint s-460 labo da 1 concept of "functional dependence" (R-dependence) and its relation Sand and the second set but at B. Laigner Brand Bail to "structure-based" capability functions. The results of this Linshund for sing unjag als agreesed. C. C. accigez. investigation include some basic theorems characterizing like of the error of which of which a solution of the solution R-dependence and R-dependent sets when the index set D is count-- METERS - Constrained and the second straight the first strain the strain ably infinite. (Similar results obtained during the previous an an an Arthur and the state of the second s reporting period [3] assumed a finite index set.) Of more ..... ----practical signifigance, however, is the use of these basic theorems to establish the fundamental limitations of reliability modeling that is based on "structure functions" or, equivalently, their representation by "fault-trees". In particular, it is shown . . . . . . (Theorem 6) that any phased system model, wherein the capability function can be described by a sequence of structure functions (fault-trees), is characterized by a total absence of R-dependence among the phases (where R is the set of all state trajectories corresponding to system "success"). One of the features of performability modeling, on the other hand, is its ability to accomodate interphase dependencies, as illustrated in the conclusion of Section 3.1.

Section 3.2 reviews our progress in the development of METAPHOR, a prototype software package to aid the evaluation of performability. This includes a discussion of the objectives and abilities of METAPHOR as well as a description of how the current implementation of the package is used. Effort has also been devoted to producing more detailed documentation of how METAPHOR is implemented. This documentation effort is still in progress, however, and will be completed during the next reporting period. A full report of this activity will be included in the next Semi-Annual Status Report.

Section 3.3 concerns the major part of our activity during the reporting period, a relatively comprehensive performability modeling and evaluation exercise involving the SIFT computer [8]. The computational environment is assumed to be a transoceanic flight of a commercial aircraft and the accomplishment set A is naturally defined in terms of attributes used by Ratner, et. al. [7] to distinguish the "criticalities" of various aircraft functions. The capability function  $\gamma_S$  of the "total system" (SIFT plus its environment) is described in terms of a 3-level model hierarchy, where each step of the modeling process is explained in considerable detail. Performability is then evaluated using the basic two-step computational procedure described previously (see [3], [4], for example), that is,

> 1) For each accomplishment level in A, determine the set of all state trajectories that result in a, that is, determine the inverse image  $U_a = \gamma_s^{-1}(a)$ ,

2) Using the base model X<sub>S</sub>, for each a in A, compute the probability of the trajectory set U (which is equal to the performability value<sup>a</sup>p<sub>S</sub>(a)).

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Implementation of step 1) is described in more detail than it has been in the reports of previous evaluation exercises. In both steps, computations were aided by the current version of METAPHOR but many of the calculations, particularly in step 1), remain to be automated. This necessitated a great deal of tedious manual computation and resulted in computational errors that were fficult to locate. However, the results finally obtained appear to be correct since they satisfy several consistancy checks. More importantly, we believe that the work described in Section 3.3 comprises a significant step toward establishing the practicality of performability evaluation, particularly as it applies to aircraft computing systems.

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### 3.1 Functional Dependence

During the reporting period, our investigation of the concept of "functional dependence" has continued with an emphasis on i) extending the theory to (countably) infinite coordinate sets and ii) using the theory to characterize the limitations of traditional structure-based reliability analysis. Although specific results of this effort have already been documented in a paper presented at the 1978 Johns Hopkins Conference (see [5]), the discussion that follows links the work of the current period to that described in previous reports and, thereby, serves to clarify the progress during the current reporting period.

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## 3.1.1 Extension of the Definition of R-dependence

Prior to the reporting period, the investigation of functional dependence or, more formally, "R-dependence" has presumed that the underlying index set D (see [3], p. 28, Def. 1) is finite. Although not stated explicitly in Def. 1, the finiteness assumption becomes apparent in Def. 2 ([3], p.29) and is used in the proof of theorem 4 ([3], p.41). In our current applications of functional dependence, the index sets D are indeed finite since the indicies correspond to the decomposition of the state space into a finite number of component spaces and/or the decomposition of the utilization period into a finite number of phases. However, we anticipate applications where the user will be interested in longrun performability, in which case the utilization period may be In such cases, assuming that each phase has finite duraunbounded. tion, the number of phases will be countably infinite. To accommodate such situations, we have extended the definition of R-dependence to include infinite index sets and have reexamined the theory of R-dependence in the light of this extension.

To begin, the system coordinates (whether distinguished in time, space, or both) are represented by 1 countable set D, called the <u>index set</u>, where, as earlier, we assume that D is totally ordered relative to some underlying ordering relation. For example, if S is a system with n subsystem  $S_1, S_2, \ldots, S_n$  and the long-run behavior of the system is observed at discrete times  $t'_1, t'_2, t'_3, \ldots$ then

 $D = \{ \{(i,j) \mid i \in \{1,2,\ldots,n\}, j \in \{1,2,3,\ldots\} \}$ 

where (i,j) represents subsystem  $S_i$  observed at time t. D is then totally ordered in some convenient way, e.g., by the relation  $\leq$  where

(a,b)  $\leq$  (c,d) if a < cor a = c and  $b \leq d$ .

Relative to D and some family of sets

$$\mathcal{Q} = \{Q_d \mid d \in D\}$$

indexed by D, the concept of R-dependence is based on the following types of sets.

Definition 1: A structured set (relative to D and  $\mathscr{Q}$ ) is a subset of the Cartesian product of the sets in  $\mathscr{Q}$ , that is,

where the product is taken according to the ordering of D.

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In the context of Definition 1, deD is a coordinate and  $Q_d$  is the <u>range</u> of coordinate d. A set C<sub>S</sub>D is called a <u>coordinate</u> <u>set</u>; the coordinates in C are subject to the ordering relation imposed on D.

When dealing with structured sets it is convenient to refer to the values taken on by a particular coordinate or set of coordinates. If dcD, let  $\xi_d : R \rightarrow Q_d$  denote the projection of R on d, that is,

 $\xi_{d}(r_{1}, \ldots, r_{d}, \ldots) = r_{d}$ 

Extending such projections to coordinate sets: <u>Definition 2</u>: If C<sub>C</sub>D is a coordinate set where  $C = \{c_1, c_2, c_3, ...\}$ ( $c_1$  is the first element of C according to the ordering of D,  $c_2$ is the second element, etc.) the projection of R on C is the function

$$\xi_{C}: \mathbb{R} \rightarrow \chi_{C} Q_{C}$$

where  $\xi_{C}(r) = (\xi_{c_1}(r), \xi_{c_2}(r), \xi_{c_3}(r),...)$ . If  $C = \phi$  (the empty set),  $\xi_{\phi}: \mathbb{R} \rightarrow \{1_{\phi}\}$  where  $1_{\phi}$  is an arbitrary constant.

For example, suppose D = {1,2,3} with the natural ordering, and Q<sub>1</sub> = {0,1}, icD. Then  $\xi_{\{1,2\}}((0,1,1)) = (0,1)$ , and  $\xi_{\{3\}}((1,1,0))$ . = (0). When C is a singleton set{d},  $\xi_{\{d\}}$  will usually be denoted as  $\xi_{d}$ .

With the above preliminaries and with a slight notational change to eliminate some confusion that arose in the previous status report, R-Dependence is defined as follows.

Definition 3: If R is a structured set (relative to D and  $\mathcal{Q}$ ) and A, B  $\subseteq$  D then A <u>R</u>-depends on B (denoted A  $\Delta_{R}$  B) if  $\exists v \in \xi_{A}(R), \exists w \in \xi_{B}(R)$  such that  $\forall r \in \mathbb{R}$   $[\xi_B(r) = w \text{ implies } \xi_A(r) \neq v]$ . A is <u>R-independent</u> of B (A  $\not A_R$  B) if A does not R-depend on B.

The implications of the above definition, when so extended to permit a countably infinite index set D, are examined in the subsections that follow.

### 3.1.2 Basic Properties

Regarding  $\Delta_{R}$  ("R-depends on") as a relation on the set of all subsets of the index set D (i.e., the "power set" of D), we note, first of all, that the global properties of  $\Delta_{R}$  are preserved when D becomes countably infinite. In particular, as established earlier for finite D, we find that  $\Delta_{R}$  is symmetric but generally neither reflexive nor transitive. The symmetry of  $\Delta_{R}$  (i.e., A  $\Delta_{R}$  B implies B  $\Delta_{R}$  A) follows immediately from Definition 3 for if v and w are such that  $[\xi_{B}(r) = w$  implies  $\xi_{A}(r) \neq v]$  then  $[\xi_{A}(r) = v$  implies  $\xi_{B}(r) \neq w]$ . Regarding reflexivity, if CSD it follows that C R-depends on C if and only if  $|\xi_{C}(R)| > 1$ . (If  $|\xi_{C}(R)| > 1$  any two distinct elements of  $\xi_{C}(R)$  can serve as the v and w of bef. 3; if  $|\xi_{C}(R)| = 1$ , distinct elements u and v do not exist and, hence, C can not R-depend on C.)

Accordingly,  $\Delta_R$  is generally not reflexive since there may exist a coordinate set C for which  $|\xi_C(R)| = 1$ , i.e., its projection is a constant. On the other hand, in the special case where no such coordinate sets exist, it follows that  $\Delta_R$  is a reflexive relation. Finally, as demonstrated in the previous report using the structured set R = {(0,0,0), (0,0,1), (1,0,0), (1,1,1)} (see [3], p.35),  $\lambda_R$  is generally not a transitive relation. (This finite example

W

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suffices since the generalization to countable index sets D includes the special case where D is finite.)

The alternative characterizations of R-dependence (see [3], p. 34, theorem 1) also hold when D is countable, where we have found that the "partition characterization" (part iii) of Theorem 1) is especially useful. In the interest of clarity, this characterization will be restated using the notation of Def. 3, and then proved directly (as opposed to the earlier proof which involved two characterizations). The partition characterization is motivated by the fact that the "knowledge" or "information" conveyed by a coordinate set C can be regarded as classification of sequences in R, where two sequences are in the same class if they have the same projection on More precisely, if  $C \subseteq D$  let  $\Xi_{C}$  denote the "equivalence kernel" of с.  $\xi_{\rm C}$ , i.e., for all r, seR, r = s iff  $\xi_{\rm C}(r) = \xi_{\rm C}(s)$ , and let  $\pi_{\rm C}$  denote the partition of R induced by  $\Xi_{c}$ , that is,  $\pi_{c}$  is the set of all equivalence classes of  $\equiv_{C}$ . Finally, if  $v \in \xi_{C}(R)$ , let  $\mathbb{B}_{C}(v)$  denote the "block" of  $\pi_{C}$  (equivalence class of  $\Xi_{C}$ ) determined by v, that is,  $\mathbb{B}_{C}(v) = \{r \in \mathbb{R} | \xi_{C}(r) = v\}$ . Then, in terms of these partitions, the concept of R-dependence can be characterized as follows.

<u>Theorem 1</u>: Let R be a structured set indexed by D, and let  $A, B \subseteq D$ . Then A R-depends on B if and only if  $\exists v \in \xi_A(R)$ ,  $\exists w \in \xi_B(R)$  such that  $\mathbb{B}_A(v) \cap \mathbb{B}_B(w) = \phi$ .

<u>Proof</u>: Suppose  $A \ \Delta_R \ B$ , and let v, w be as in Definition 3, i.e.,  $\forall r \in R[\xi_B(r) = w \Rightarrow \xi_A(r) \neq v]$ . But  $\xi_B(r) = w \Leftrightarrow r \in \mathbb{B}_B(w)$ , and  $\xi_A(r) \neq v \Leftrightarrow r \notin \mathbb{B}_A(v)$ . Hence,  $\forall r \in R[r \in \mathbb{B}_B(w) \Rightarrow r \notin \mathbb{B}_A(v)]$  which, in turn, implies that  $\mathbb{B}_A(v) \cap \mathbb{B}_B(w) = \phi$ . Conversely, suppose  $\exists v \in \xi_A(R)$ ,  $\exists w \in \xi_B(R)$ 

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such that  $\mathbb{B}_{A}(v) \cap \mathbb{B}_{B}(w) = \phi$ . Then  $\forall r \in \mathbb{R}$ , whenever  $\dot{r} \in \mathbb{B}_{B}(w)$ , it must be the case that  $r \notin \mathbb{B}_{A}(v)$ . Therefore,  $\forall r \in \mathbb{R}[\xi_{B}(r) = w \Rightarrow \xi_{A}(r) \neq v]$ .

Theorem 1 thus provides a convenient algebraic characterization of R-dependence which, given partitions  $\pi_A$  and  $\pi_B$ , says that A R-depends on B if and only if there is a block in  $\pi_A$  and a block in  $\pi_B$  which have no elements in common.

Using Theorem 1, we can derive additional properties of R-dependence which are useful when searching for R-dependencies. As was the case for finite D (see[3], p.36, Lemmal) we observe, first of all, that if A  $\Delta_R$  B then supersets of A must R-depend on supersets of B, that is:

<u>Theorem 2</u>: Let  $A, B \subseteq D$ . If  $A \land_R B$  then,  $\forall A' \supseteq A$  and  $\forall B' \supseteq B$  such that  $A', B' \subseteq D, A' \land_R \neg B'$ .

Proof: Suppose A  $\Delta_R$  B and let A'2A, B'2B. Then  $\exists v \in \xi_A(R)$ ,  $\exists w \in \xi_B(R)$ such that  $\mathfrak{B}_A(v) \cap \mathfrak{B}_B(w) = \phi$ . For any A'2A, it follows immediately that  $\pi_A$ , refines  $\pi_{A'}$ , i.e., each block in  $\pi_{A'}$  is a subset of some block in  $\pi_A$ . Hence  $\exists v' \in \xi_{A'}(R)$  such that  $\mathfrak{B}_{A'}(v') \subseteq \mathfrak{B}_A(v)$ , and  $\exists w' \in \xi_{B'}(R)$ such that  $\mathfrak{B}_B(w') \subseteq \mathfrak{B}_B(w)$ . As  $\mathfrak{B}_A(v) \cap \mathfrak{B}_B(w) = \phi$ , we have  $\mathfrak{B}_{A'}(v) \cap$  $\mathfrak{B}_B(w') = \phi$  and therefore A'  $\Delta_B$  B'.

Theorem 2, which says that dependence is preserved by supersets, has the following "dual" statement which says that independence is preserved by subsets, that is:

<u>Theorem 3</u>: Let A, B  $\subseteq$  D. If A  $\measuredangle_R$  B then,  $\forall A' \subseteq A$ ,  $\forall B' \subseteq B$ ,  $A' \checkmark_R B'$ . <u>Proof</u>: Suppose to the contrary, i.e., there is a subset A' of A

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and a subset B' of B such that A'  $\Delta_R$  B'. Then, by Theorem 2, A  $\Delta_R$  B. contradicting the assumption that A  $\beta_P$  B.

The utility of Theorems 2 and 3 is that additional dependencies and independencies can be inferred from those already known. Finally, as observed earlier for finite index sets (see [3], p. 39, Theorem 3), the notion of R-independence, that is, the complement of the relation  $\Delta_R$ , is closely related to the notion of a Cartesian product. More precisely,

<u>Theorem 4</u>: Let A,BCD be disjoint coordinate sets, and let  $\psi:\xi_{AUB}(R) \rightarrow \xi_A(R) \times \xi_B(R)$  be a mapping such that  $\forall r \in R[\psi(\xi_{AUB}(r)) = (\xi_A(r), \xi_B(r))]$ . (Such a map  $\psi$  always exists and is unique.) Then A  $\measuredangle_R$  B if and only if  $\psi(\xi_{AUB}(R)) = \xi_A(R) \times \xi_B(R)$ .

<u>Proof</u>: Suppose A  $\Delta_R$  B. It suffices to show that  $\psi$  is-onto. Let  $v \in \xi_A(R)$ ,  $w \in \xi_B(R)$ . By the definition of R-independence,  $\exists r \in R[\xi_B(r) = w$ and  $\xi_A(r) = v]$ . Accordingly  $\psi(\xi_{AUB}(r)) = (\xi_A(r), \xi_B(r)) = (v, w)$ . Conversely, suppose  $\psi$  is onto. Then  $\forall v \in \xi_A(R)$  and  $\forall w \in \xi_B(R)$ ,  $\exists r \in R[\psi(\xi_{AUB}(r)) = (v, w)]$ . Hence,  $\exists r \in R[\xi_B(r) = w$  and  $\xi_A(r) = v]$ , i.e., A  $\measuredangle_R$  B.

An even stronger link between functional independence and Cartesian products is developed in the following subsection.

### 3.1.3 R-dependent Coordinate Sets

When examining the nature of a structured set R, it is often convenient to identify coordinate sets C ( $C \subseteq D$ ) for which R-dependencies exist among the subsets of C. In the terminology of generalized dependence relations (see[Naylor]), such a set C is referred to as being "dependent" (in itself). When C is finite, this concept can be defined rather naturally, as was done during the previous reporting period (see [3], p. 37, Def. 5). However, when C is infinite (which is now a possibility since D may be infinite) the choice of an appropriate definition of "self-dependence" is less clear. On examining the alternatives, our choice was dictated by the desire to have a constructive test for R-dependence, even when C is infinite. Accordingly, the notion of self-dependence is formally defined as follows.

Definition 4: If R is a structured set indexed by D and C D then C is <u>R-dependent</u> if there exist finite sets A, B C with A B =  $\phi$  such that A  $\Delta_R$  B. C is <u>R-independent</u> if C is not R-dependent.

The requirement that the subsets A and B be finite provides the kind of constructive test referred to above. This is analogous to what is done in linear algebra where a dependent set of vectors must contain a finite subset for which some linear combination yields the zero vector of the space. The requirement that  $A\cap B = \phi$  insures that C is not regarded as R-dependent simply because some subset of C depends on itself.

Applying Theorem 4, an R-independent set C can be characterized in terms of the algebraic structure of  $\xi_{C}(R)$  as follows. (This characterization reduces to Theorem 4, p.41 in [3] when D is assumed to be finite.)

<u>Theorem 5</u>: If R is a structured set indexed by D and C  $\subseteq$  D, then C is R-independent if and only if  $\xi_{C}(R) = \bigwedge_{d \in D} \xi_{d}(R)$ .

Proof: Suppose that  $\xi_{C}(R) = \begin{pmatrix} \chi & \xi_{d}(R) \end{pmatrix}$ . Let A and B be finite disjoint subsets of C. Then  $\xi_{A}(R) = \begin{pmatrix} \chi & \xi_{d}(R), \xi_{B}(R) \end{pmatrix} = \begin{pmatrix} \chi & \xi_{d}(R) \end{pmatrix}$  and  $d \in A$ 

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 $\xi_{AUB}(R) = \chi_{d \in AUB} \xi_{d}(R)$ . Let  $\psi$  be the unique coordinate mapping described in Theorem 4. Then  $\psi(\xi_{AUB}(R)) = \psi(\chi_{d\epsilon AUB} \xi_{d}(R)) = d\epsilon_{AUB}$ ( $\chi_{d\epsilon A} \xi_{d}(R)$ ) × ( $\chi_{d\epsilon B} \xi_{d}(R)$ ) =  $\xi_{A}(R) \times \xi_{B}(R)$ . Thus by Theorem 4, A  $\beta_R$  B. Since this is true for arbitrary, finite, disjoint sets A, B  $\subseteq$  C, this implies that C is R-independent. Conversely, suppose C is R-independent, that is, for all finite sets A,BGC such that  $A\cap B = \phi$ ,  $A \land_R B$ . Relabel the elements  $c_1, \ldots, c_m, \ldots$  of C as 1, ..., m, ... Then, in particular, {1}  $\Delta_R$  {2}. Applying Theorem 4 with A = {1} and B = {2},  $\psi(\xi_{\{1,2\}}(R)) = \xi_1(R) \times \xi_2(R)$ . Because 1 is the first coordinate in C,  $\psi$  is just the identity function, that is,  $\psi(\xi_{\{1,2\}}(R)) = \xi_{\{1,2\}}(R) = \xi_1(R) \times \xi_2(R)$ . Now take A = {1,2} and B = {3}. Then {1,2}  $\Delta_R$  {3} so  $\psi(\xi_{\{1,2,3\}}(R)) = 1$  $\xi_{\{1,2,3\}}(R) = \xi_{\{1,2\}}(R) \times \xi_{\{3\}}(R)$  by Theorem 4... Once again  $\psi$  is just the identity, so  $\xi_{\{1,2,3\}}(R) = \xi_{\{1,2\}}(R) \times \xi_{3}(R)$ , and, by substitution,  $\xi_{\{1,2,3\}}(R) = \xi_1(R) \times \xi_2(R) \times \xi_3(R)$ . Continuing in this fashion, we can conclude that  $\xi_C(R) = \chi_{deC} \xi_d(R)$ .

<u>Corollary</u>: If R is indexed by D then D is R-independent if and only if R is a Cartesian product, that is,  $R = \chi \xi_d(R)$ .  $d \epsilon D$ 

The "if" part of the corollary says that, whenever R is Cartesian, the index set D must be completely free of R-dependencies (in the sense of Definition 4), as one would expect given the original definition of R-dependence (Definition 3). The "only if" part is a little more surprising in that the absence of R-dependencies among finite subsets of D (even when D is infinite) guarantees that D will have the simple structure of a Cartesian product.

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### 3.1.4 Characterization of Structure-based Capability

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In addition to the above extension of the theory of Rdependence, we have explored the role that R-dependence plays in performability evaluation and, particularly, how this concept might be used to distinguish basic differences between performability modeling (as developed under the subject grant) and traditional During the previous reporting period, using reliability modeling. an example wherein success was identified with a minimum allowable average throughput (i.e., the capability function designated  $\gamma_2$ example 1, pp. 18-20 of [3]), it was argued that capability functions are more general than the "structure functions" of phased-mission reliability modeling [9]. (A somewhat more detailed version of this argument appears in [[ 4 ].) During the reporting period, however, we have found that the inherent limitations of structure functions can be much more clearly and precisely characterized via the concept of R-dependence.

To establish this characterization, suppose  $X_s$  is a base-model with state space Q and one is more interested only in the reliability of the system, that is, the accomplishment set is  $A = \{0,1\}$  (where 1 denotes " success" and 0 "failure"). Then, extending the notion of a "structure-based" capability function (see [3], p.17) to include "phased missions" (see [.9]), a capability function  $\gamma_s$  is <u>structure-based</u> if there exists a decomposition of T into k consecutive time periods  $T_1, T_2, \ldots, T_k$  and there exist functions  $\varphi_1, \varphi_2, \ldots, \varphi_k$  with  $\varphi_i: Q \rightarrow \{0,1\}$  such that, for all usU,

 $\gamma_{S}(u) = 1$  if  $\phi_{i}(u(t)) = 1$ ,

for all is  $\{1, 2, \ldots, k\}$  and for all teT. In the context of phased

mission analysis,  $T_i$  is referred to as the i<sup>th</sup> phase (of the mission) and  $\varphi_i$  is the structure function of the i<sup>th</sup> phase. Assuming further (as does phased mission analysis) that  $\varphi_i(u(t)) = 1$ , for all  $t \in T_i$ , whenever  $\varphi_i(u(t_i)) = 1$  where  $t_i$  is the end of  $T_i$ , the trajectory space U can be represented by the Cartesian product U =  $Q^k$ . Accordingly, if  $u = (q_1, q_2, \ldots, q_k)$ , then  $\gamma_S(u) = 1$  iff  $\varphi_i(q_i) = 1$ , for all  $i \in \{1, 2, \ldots, k\}$ . Hence  $u \in \gamma_S^{-1}(1)$  iff  $\xi_i(u) \in \varphi_i^{-1}(1)$ for all  $i \in \{1, 2, \ldots, k\}$  and we conclude that the set  $R = \gamma_S^{-1}(1)$ of "success trajectories" is also Cartesian, i.e.,

Conversely, whenever a capability function  $\gamma_{S}: Q^{k} \rightarrow \{0,1\}$  is such that  $R = \gamma_{S}^{-1}(1)$  is Cartesian, it admits to a structure-based formulation by choosing each  $\varphi_{i}$  such that  $\varphi_{i}(q) = 1$  iff  $q \in \overline{\xi_{i}(R)}$ . Appealing to the corollary of Theorem 5, we have proved:

 $R = \chi_{i-1}^{k} \varphi_{i}^{-1}(1)$ .

<u>Theorem 6</u>: Let S be a phased system with trajectory space  $U = Q^k$ and capability function  $\gamma_S: U \to \{0, 1\}$ . Then  $\gamma_S$  is structure-based if and only if the set of all phases  $D = \{1, 2, ..., k\}$  is R-independent, where  $R = \gamma_S^{-1}(1)$ .

In other words, the absence of R-dependence between phases characterizes structure-based capability functions and, accordingly, reveals the inherent limitations of structure-based reliability analysis Performability analysis, on the other hand, can accommodate interphase dependencies, as demonstrated by the following example.

Suppose S is a multiprocessor system with three processors where the performance in question is the average throughput (Th av) of the system. Suppose further that the processors are identical,

so that the processing rate of the system is determined only by the number of fault-free processors. More precisely, let us suppose that the state set of the base model is  $Q = \{0,1,2\}$  where the states in Q have the following interpretation:

> 0: all processors fault-free

one processor faulty 1:

two or more processors faulty 2:

Suppose further that, relative to a maximum throughput (processing rate) T, the throughput associated with each state is as follows:

> Throughput willing to the second seco State 0:  $\tau/2$ 1:

If the utilization period is divided into phases of equal duration and we make the pessimistic assumption that the loss of a processor during a phase will affect the throughput to the same degree as the loss of a processor at the beginning of that phase, then the trajectory space of the base model is represented by the set

0

2

$$J = \{ (q_1, q_2, q_3) | q_i \in Q \}$$

2:

where q; is the state of the system at the end of phase i. For the user oriented model, suppose that the accomplishment set is A = {a, a, a, a, a} where a corresponds to Th<sub>av</sub>  $\geq$  5 $\tau/6$ , a corresponds to  $5\tau/6 > Th_{av} \ge \tau/2$ , and  $a_2$  corresponds to  $Th_{av} < \tau/2$ . Then the capability function  $\gamma_S$  is given by:

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u .	γ <sub>S</sub> (u)
(0,0,0)	a <sub>0</sub>
(0,0,1)	a <sub>0</sub>
(0,0,2)	a <sub>l</sub>
(0,1,0)	<sup>a</sup> 0
(0,1,1)	al
(0,1,2)	a <sub>1</sub>
•	•
•	•
internationalista Antonio antonio	•
(2,2,2)	a2.

To illustrate interphase dependence, suppose we know that the accomplishment level is  $a_0$  and let  $R = \gamma^{-1}(a_0) = \{(0,0,0), (0,0,1), (0,1,0), (1,0,0)\}$ . If  $u_{\epsilon}R$  and we know that  $q_2 = 1$ , then we can infer that  $q_1 \neq 1$ . Thus, knowledge of the state of the system at the end of the second phase has increased our knowledge about the state of the system at the end of the system at the previous phase. More formally, in terms of Def. 3, if  $A = \{1\}$ ,  $B = \{2\}$  then v = 1 and w = 1 guarantee that  $\{1\} \Delta_R \{2\}$ , i.e., phase 1 R-depends on phase 2.

In general, we have found that such temporal functional dependencies arise quite naturally when accomplishment levels are associated with user-visible performance. Of particular importance is the fact that such dependencies arise in the context of aircraft computer performability evaluation, as was observed during the prototype modeling and evaluation exercise conducted during the previous period (see [3], pp. 169-170). Further evidence of this fact has been revealed by the work of the current reporting period where, in evaluating the performability of the SIFT computer (see section 3.3 of

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this report), we have found that there is an extensive amount of interphase dependency and, indeed, more than we had originally anticipated.

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#### 3.2 Evaluation Algorithms and Programs (METAPHOR)

Concurrent with the development of performability models, concepts, measures, and measure formulations, we have proceeded with the development of evaluation algorithms and prototype evaluation tools for the purpose of investigating the feasibility of our overall approach. In particular, we are referring here to the software package called METAPHOR (Michigan Evaluation Aid for Perphormability), whose development was initiated during the previous reporting period (see [3], Section 3.5.8.1). The following sections discuss this package and the tools it contains. Detailed documentation of METAPHOR is currently in progress and will be included in the next Semi-Annual Status Report. Section 3.2.1 expands upon the objectives and abilities of METAPHOR, while Section 3.2.2 describes its use. Finally, Section 3.2.3 examines the internal structure of METAPHOR.

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## 3.2.1 Objectives and Abilities

We envision METAPHOR as ultimately containing all the programmed tools necessary to realize a complete performability evaluation. These include aids for a) constructing the model hierarchy, b) determining the interlevel translations and their inverses, c) determining the base model trajectory sets associated with accomplishment levels , and d) evaluating the probabilities of these trajectory sets (i.e., the sets  $\gamma^{-1}$  (a) for each a:A). In addition, because of METAPHOR's ability to provide instruction via devices such as the HELP command, we view METAPHOR as a performability evaluation tutor.

Of the above tools, METAPHOR currently contains substantial

elements of the last two, i.e., routines to calculate the probabilities of trajectory sets in addition to some tutorial capabilities. That is, once the analyst has derived the interphase and intraphase transition (P and H) matrices along with the corresponding trajectory sets of each accomplishment level, METAPHOR can then be used to calculate the probability of each accomplishment level. Presently, METAPHOR also has the ability to compute certain classes of transition matrices given such information as the structure of the components (e.g., whether computer modules are connected in a Triple Modular Redundant (TMR) fashion), and the failure rates of those components and the duration of the phase.

METAPHOR's tutorial facilities are based on an extensive repertoire of replies to HELP requests, along with preprogrammed series of questions relating to specific topics. This last feature is intended to aid a person who is learning to use the evaluation programs .

3.2.2. Use of METAPHOR

This section contains a summary of the commands and options currently implemented in METAPHOR. These are HELP, BRIEF, ECHO, EXIT, DATA, ALTER, GIVEN, DEDFAIL, NFAIL, IDENTITY, COM, and CALC. More detailed documentation of these items is currently in progress and will be reported in the next Semi-Annual Status Report.

When METAPHOR is first run, an initial heading is printed, followed by a prompt sign:

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#### **METAPHOR**

#### <u>MICHIGAN EVALUATION AID FOR PERPHORMABILITY</u> VERSION 2 5/78

TYPE HELP FOR ASSISTANCE :

The quad followed by a colon is the prompt symbol indicating that METAPHOR is ready for some form of input. Three types of input may be entered. In response to most questions, numerical data is required, while a few questions need a yes/no type answer. The third type of input encompasses the command language of METAPHOR. Commands may be entered at any time, even in response to questions. (The present version does not recognize commands in answer to a yes/no question.) After the. command is executed, the initial question is repeated-(if appropriate).

If the user needs further assistance at some point in the program, he can enter HELP. This prints an explanation of what to do next or a brief discussion of the idea or concept currently being utilized. Also, if the user desires, a list of references concerning that idea or concept is printed. For example, if METAPHOR asks what type of interphase transition matrix is required, the user may type HELP to learn that four options are available: GIVEN, DEDFAIL, NFAIL, and IDENTITY. Further information, if requested, describes each option in detail.

Two commands are useful when supplying input from a source other than the user terminal (e.g., input from a disk file or from cards in batch mode). These are BRIEF and ECHO. BRIEF is used to suppress all output except the final results, while ECHO is employed to repeat the user supplied input. The conditions are activated by entering ECHO ON, ECHO OFF, BRIEF ON, or BRIEF OFF. The default is BRIEF OFF, ECHO OFF.

At any time, the program can be halted by entering EXIT. This causes an immediate termination of the program; it cannot be restarted.

Evaluation of trajectory set probabilities is accomplished using the EVAL command. This command initiates a sequence of queries by which METAPHOR receives a description of the trajectory sets and related items describing  $\gamma^{-1}$ . METAPHOR asks the following questions:

How many phases?
How many states in each phase?
What are the intraphase transition matrices (P)
for each phase?
What are the interphase transition matrices (H)
for each phase?
How many time-invariant variables?
What is the probability distribution of each time-
invariant basic variable?
For each accomplishment level:
a) How many Cartesian trajectory sets?
b) For each Cartesian trajectory set:
i) What is the initial state vector
(I)?
ii) What are the main diagonals of the
characteristic matrices (G)?
iii) What is the characteristic vector
(F)?
iv) What are the values of the time-
invariant basic variables?

METAPHOR calculates the probability of each trajectory set "on the fly," i.e., as each Cartesian component is entered, its contribution to the overall probability is determined; the trajectory set is then discarded. (This method reduces the amount of storage nearly to perform the calculations.) The

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result in the form of a list (performability spectrum) is then printed. Also, if the result does not sum to 1, an error message is printed.

Currently, four types (or classes) of intraphase matrices (P) and two types of interphase matrices (H) can be entered. For the P matrices, these are GIVEN, IDENTITY, NFAIL, and DEDFAIL, while for the H matrices, either GIVEN or IDENTITY can be specified.

GIVEN allows the user to input a matrix row by row. IDENTITY automatically generates an identity matrix of the proper size.

DEDFAIL and NFAIL compute transition matrices for an special types of systems. Each assumes that the structure of the system is described in terms of "components" where the state of each component is either "operational" or "failed," Both DEDFAIL and NFAIL assume that all components are alike and fail independently with the same constant failure rate. Finally, components are assumed to fail permanently, i.e., once a component has failed, it remains failed for the duration of the phase. The difference between the two lies in how the states of the system are defined in terms of component status. DEDFAIL keeps track of each component in the system, i.e., whether a given component is operational or failed can be deduced from the state of the system. In METAPHOR, the most important use of DEDFAIL is in modeling a system wherein each component (e.g., processor) is dedicated to a different task (hence the name DEDFAIL). In such situations, the processing capability generally depends on the state of each component and hence the

system state must convey the state of each component.

NFAIL, on the other hand, assumes that the components of the system are lumped into groups. NFAIL then keeps track only of the number of components which are operational within each of these groups. For instance, if two tasks and four processors are configured such that two processors are executing each task, then failure of either processor assigned to a given task will have the same effect on system performance. Accordingly, processors sharing the same task can be lumped, resulting in 2 groups with 2 processors per group. NFAIL is equivalent to DEDFAIL when NFAIL has n groups of 1 element each.

If at any time the user wishes to know what value METAPHOR has assigned to some variable, or if the user wishes to change the value of some variable, then the commands DATA or ALTER may be employed. DATA causes two lines of abbreviations to be printed`as below:

□:

DATA

PUT AN X BELOW EACH ITEM-TO BE DISPLAYED. HELP AVAILABLE. NUM.PHASES NUM.STATES P H NUM.CONST.BAS.VARS PROB.CONST.BAS.VARS X X NUM.ACC.LEVELS NUM.TRAJ.SETS I G F V PERF X X

The user places an X below the items he wishes to display. Each item is printed so long as it has been defined, otherwise a warning is given stating that the item has not been defined. The above abbreviations should be straightforward; note that time-invariant basic variables are referred to as "constant" basic variables (CONST.BAS.VARS), "NUM" stands for "number of," while "ACC" for "accomplishment," and "TRAJ" for "trajectory." V is the vector characterizing the time-invariant basic variables.

ALTER operates in a manner similar to DATA. One line of abbreviations is presented:

C: ALTER PUT AN X BELOW EACH ITEM TO BE CHANGED. HELP AVAILABLE. P H CONST.BAS.VARS ALL.ACC.LEVELS PRESENT.ACC.LEVEL I G F V NUM.TRAJ.SETS X X

Again the user places an X below each item to be changed. This command is particularly useful if an error is made while entering data.

Two other commands are available. COM allows the user to enter lines of text as comments. METAPHOR will prompt each line with "\*\*\*", after which any characters may be typed. Giving a carriage return with no characters (a null line) ends the comment section. CALC allows the user to utilize the APL calculator mode. Each line will be prompted by a question mark, a quad and then a colon as follows:

□: *CALC* 2 □:

The user is advised not to employ assignment statements (such as  $A \\le 6$ ), since the names of variables chosen may interfere with names of variables internal to METAPHOR. When in CALC mode, typing EXIT returns the user to his previous status, i.e., the state of the program before CALC mode was entered.

Figures 1-2 give sample METAPHOR sessions.

<u>MICHIGAN EVALUATION AID FOR PERPHOR</u>MABILITY VERSION 2 5/78

TYPE HELP FOR ASSISTANCE ECHO ECHO ON D: EVAL

NUMBER OF PHASES?

NUMBER OF STATES PER PHASE? (SPACE BETWEEN EACH NUMBER) [: 3 2

SPECIFY THE P MATRICES FOR EACH PHASE, 1 PHASE AT A TIME

PHASE 1:

WHAT TYPE OF P MATRIX? D: NFAIL ENTER PHASE LENGTH D: 10 ENTER COMPONENT FAILURE RATE D: 0.0001 ENTER NUMBER OF GROUPS D: 1 ENTER NUMBER OF COMPONENTS PER GROUP (SPACE BETWEEN EACH NUMBER): D: 2

PHASE 2:

WHAT TYPE OF P MATRIX? DEDFAIL ENTER PHASE LENGTH S ENTER COMPONENT FAILURE RATE 0.0001

SPECIFY THE H MATRICES FOR EACH PHASE, 1 PHASE AT A TIME

PHASE 1-2:

WHAT TYPE OF H MATRIX? : GIVEN ENTER THE MATRIX, 1 ROW AT A TIME

> FIGURE 1 Sample METAPHOR Session

ORIGINAL PAGE IN ROW 1: D: 1 0 OF POOR QUALITY. *ROW* 2: ROW 3: **[]:** 0 1 NUMBER OF CONSTANT BASIC VARIABLES? Π: 1 PROBABILITIES OF EACH CONSTANT VARIABLE? (SPACE BETWEEN EACH NUMBER) □: 0.001 NUMBER OF ACCOMPLISHMENT LEVELS? []: 3 . . . ACCOMPLISHMENT LEVEL O NUMBER OF TRAJECTORY SETS FOR THIS ACCOMPLISHMENT LEVEL? []: 1 TRAJECTORY SET 1 ENTER THE I VECTOR (SPACE BETWEEN EACH ENTRY):  $\Box: 1 \quad 0 \quad 0$ PHASE 1: ENTER THE G DIAGONAL (SPACE BETWEEN EACH ENTRY): []: 1, 0, 0ENTER THE F VECTOR (SPACE BETWEEN EACH ENTRY):  $\Pi: 1 0$ ENTER THE 1 ELEMENT CONSTANT BASIC VARIABLE VECTOR (SPACE BETWEEN EACH ENTRY): **[]:** 0 ACCOMPLISHMENT LEVEL 1 NUMBER OF TRAJECTORY SETS FOR THIS ACCOMPLISHMENT LEVEL? □: 2 TRAJECTORY SET 1 ENTER THE I VECTOR (SPACE BETWEEN MACH ENTRY): PHASE 1: ENTER THE G DIAGONAL (SPACE BETWEEN EACH ENTRY):  $\Pi: 0 1 0$ ENTER THE F VECTOR (SPACE BETWEEN EACH ENTRY):  $\Box: 1 0$ ENTER THE 1 ELEMENT CONSTANT BASIC VARIABLE VECTOR (SPACE BETWEEN EACH ENTRY): []: 2 TRAJECTORY SET 2 ENTER THE I VECTOR (SPACE BETWEEN EACH ENTRY):  $\Box: 1 0 0$ PHASE 1: ENTER THE G DIAGONAL (SPACE BETWEEN EACH ENTRY):  $\Pi: 1 0 0$ ENTER THE F VECTOR (SPACE BETWEEN EACH ENTRY): □: 1 0 ENTER THE 1 ELEMENT CONSTANT BASIC VARIABLE VECTOR (SPACE BETWEEN EACH ENTRY): **[]:** 1

FIGURE 1 (Continued)

فليتقدد والمحتجون بالاستع

ACCOMPLISHMENT LEVEL 2 NUMBER OF TRAJECTORY SETS FOR THIS ACCOMPLISHMENT LEVEL? [: 1 TRAJECTORY SET 1 ENTER THE I VECTOR (SPACE BETWEEN EACH ENTRY): [: 1 0 0 PHASE 1: ENTER THE G DIAGONAL (SPACE BETWEEN EACH ENTRY): [: 1 1 1 ENTER THE F VECTOR (SPACE BETWEEN EACH ENTRY): [: 0 1 ENTER THE 1 ELEMENT CONSTANT BASIC VARIABLE VECTOR (SPACE BETWEEN EACH ENTRY): [: 2

PERFORMABILITY FOR THIS MISSION + 0.0009975031224 0.9985016234 0.000500873522

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FIGURE 1 (Continued)

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#### METAPHOR

<u>MICHIGAN EVALUATION AID FOR PERPHOR</u>MABILITY VERSION 2 5/78

TYPE HELP FOR ASSISTANCE

СОМ

\*\*\* \*\*\* FIGURE 2 DEMONSTRATES SOME OF THE UTILITY \*\*\* FUNCTIONS AVAILABLE IN <u>METAPHOR</u> \*\*\*

0:

HELP

METAPHOR IS AN INTERACTIVE SOFTWARE PACKAGE AIDING THE MODELING AND ANALYSIS OF PERFORMABILITY. AT PRESENT, <u>METAPHOR</u> IS CAPABLE ONLY OF EVALUATING CERTAIN PERFORMABILITY MODELS. THE COMMANDS PRESENTLY AVAILABLE ARE: EVAL, HELP, DATA, ALTER, CALC, COM, BRIEF [ON | OFF], ECHO [ON | OFF], AND EXIT. DO YOU WANT MORE RELP?

NO

□:

EVAL

NUMBER OF PHASES?

NUMBER OF STATES PER PHASE? (SPACE BETWEEN EACH NUMBER)

12

SPECIFY THE P MATRICES FOR EACH PHASE, 1 PHASE AT A TIME

PHASE 1:

WHAT TYPE OF P MATRIX? HELP TYPE ONE OF: GIVEN, DEDFAIL, NFAIL, IDENTITY DO YOU WANT MORE HELP? NO WHAT TYPE OF P MATRIX? NFAIL

FIGURE 2 ...ple METAPHOR Session
ENTER PHASE LENGTH 2 ENTER COMPONENT FAILURE RATE 1 1 IS LARGE FOR A FAILURE RATE. DO YOU WANT THIS VALUE? NOPE ENTER COMPONENT FAILURE RATE []: . .001 ENTER NUMBER OF GROUPS □: DATA PUT AN X BELOW EACH ITEM TO BE DISPLAYED. HELP AVAILABLE. NUM.PHASES NUM.STATES P H NUM.CONST.BAS.VARS PROB.CONST.BAS.VARS - X X X · X · · · · · NUM.ACC.LEVELS NUM.TRAJ.SETS I G F V PERF X Χ . NUMBER OF PHASES IS 2 NUMBER OF STATES PER PHASE IS 1 2 P MATRICES HAVE NOT BEEN DEFINED THE CONSTANT BASIC VARIABLES HAVE NOT BEEN DEFINED THE NUMBER OF ACCOMPLISHMENT LEVELS NOT DEFINED. PERFORMABILITY NOT DEFINED ENTER NUMBER OF GROUPS 0: ALTER PUT AN X BELOW EACH ITEM TO BE CHANGED. HELP AVAILABLE. P H CONST.BAS.VARS ALL.ACC.LEVELS PRESENT.ACC.LEVEL I G F V NUM.TRAJ.SETS Х X P MATRICES ARE NOT DEFINED AT THIS TIME. THE ACCOMPLISHMENT LEVELS ARE NOT DEFINED AT THIS TIME. THE NUMBER OF TRAJECTORY SETS IS NOT DEFINED AT THIS TIME.

[]:

EXIT

FIGURE 2 (Continued) Sample Metaphor Session

## 3.2.3 Internal Structure

This section presents a brief overview of the way METAPHOR operates internally. Currently, METAPHOR is in its second major version. It is written in APL and contains approximately 2000 lines of code. The package is highly modular, with about 60 APL functions (somewhat analogous to FORTRAN subroutines). Figure 3 lists the currently available functions.

Although APL does not lend itself readily towards structured programming, a substantial effort was made to make the package easily readable and maintainable. Thus, for example, specific conventions regarding the names of functions, variables, and labels have been established.

Various methods of control and information exchange among the various functions are employed. For instance, there is a versatile input function which determines whether the item (or items) entered by the user is a command or data. If a command is given, the proper corresponding functions are then called. If data is given, a check is made to insure that it is of the correct size. Other functions check to see if the data is consistent, e.g., if a probability distribution is to be input, then it must sum to one. Some of the user assistance commands, namely HELP, ALTER, and DATA, have somewhat involved control mechanisms. For example, METAPHOR must be aware of which function it is executing in order to correctly respond to HELP requests.

More complete documentation of METAPHOR's internal structure is currently underway and will be included in the next Semi-Annual Status Report.

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Main Functions

METAPHOR DECLAREMETAPHOR METINFO

Command Functions

COMMANDALTER COMMANDBRIEF COMMANDCALC COMMANDCOM COMMANDDATA COMMANDECHO COMMANDEVAL COMMANDHELP and free of the state of the

• • •

Command Support Functions

BRIEF ECHO GETALTERVECTOR GAVINFO GETDATAVECTOR GDVINFO

Command EVAL Implementation Functions

> CETNUMPHASES GNPINFO -CETSTATES GSINFO GETPMATRICES GETHMATRICES GETNUMBASICVARIABLES NBVINFO GETBASICVARIABLES GBVINFO CETNUMACCLEV GNAINFO GETPERF **IUTPERFORMABILITY**

Matrix Generator Functions

GENERATEHMATRIX GHMINFO GENERATEPMATRIX GPMINFO GDEDFAIL GDINFO GGIVEN

GGINFO GIDENTITY GNFAIL GNINFO

Trajectory Set Evaluation Functions

	GETACCLEVPR	OB	•••
	GETNUMTRAJSI	ETS ·	
	GNTSINFO	4	<b>*</b>
	GETIVECTOR		
.,	GIVĪNFO	a na haran da sa	4
	GETGMATRICES	S .	
	GGMINFO		
	GETFVECTOR	• •	
<b>.</b>	GFVINFO	1787 - 1. State (* 181	
	GETVVALUES		
•	GVVINFO		173
	CALCTRAJPRO	В	•••

#### I/O and Checking Functions

INPUT INYES CHECKBIN CHECKPOSI CHECKPROB CHECKTRI PRINT PRINTQUAD

#### APL Support Function

ENCODE

FIGURE 3

## 3.3 <u>Performability Evaluation of the SIFT Computer in an Air</u> Transport Mission

During the reporting period, we have completed a relatively comprehensive performability modeling and evaluation exercise involving the SIFT computer [8] as it might operate in the environment of a transoceanic air transport mission. In carrying out this exercise, we have attempted to strike a balance between simplicity and reality that permits all aspects of the methodology to be demonstrated in the context of a meaningful evaluation problem. In particular, reality was stressed in the construction of higher level models, where our assumptions are based on the study of computational requirements [7]. Simplicity was stressed in made by R. S. Ratner, et al. our choice of a bottom level Markov model of the SIFT computer (similar to "Model I" used by SRI; see [8], p. 151) in order to reduce the complexity of the performability calculations. However, more realistic bottom models (e.g., SRI "Model IV") are compatible with the remainder of the hierarchy and could replace the simpler bottom model.

The description of this effort is organized as follows. First, the performance model (accomplishment set), two upper level models (mission level and aircraft functional task level), as well as the interconnections between them, are presented in Section 3.3.1. Section 3.3.2 then introduces the bottom model of the SIFT computer and describes the interlevel translation between it and the functional task level. Both the algorithm by which tasks are allocated to the computer as well as a Markov model describing the hardware are discussed. Derivations of the base model trajectory sets (associated with each level of

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accomplishment) are described in Section 3.3.3, and derivation of computer model transition matrices is described in Section 3.3.4. Finally, the numerical results of the evaluation exercise are presented in Section 3.3.5.

### 3.3.1 Higher Level Models

3.3.1.1 Performance Model

The total system S = (C, E) considered is the SIFT computer C operated in the environment E of a transoceanic flight of a commercial aircraft. The mission of the total system can be characterized as follows:

> "Transport passengers between two points (separated by an ocean) with safety, with no significant change of mission, with no significant operational penalties or stress on crew or Air Traffic Control, and with no significant economic penalties."

Examining this statement in more detail, total system performance can be described in terms of four attributes: safety, no change in mission profile, no operational penalties, and no economic penalties. Attributes similar to these have been used by Ratner, et al. [7] to distinguish the "criticalities" of various aircraft functions. To determine the accomplishment set A for the performance variable  $Y_S$ , we assume that safety is the most important attribute, i.e., safe flights have the greatest worth, the remaining attributes being worth successively less in the order they are listed above. These assumptions agree with the "reliability requirements" (see [7], p.7) associated with corresponding criticality levels. We

ORIGINAL PAGE IS OF POOR QUALITY assume further that safety is worth considerably more than no change in mission profile, which in turn is worth considerably more than no operational penalties, etc. Thus, for example, if there is a change in mission profile (i.e., loss of the attribute "no change in mission profile") then the presence or absence of lower worth attributes (i.e., "no operational penalties" and "no economic penalties") will have a negligible effect on the worth of the mission outcome.

With the above assumptions, the following set suffices to describe the relevant levels of accomplishment:

## $A = \{a_0, a_1, a_2, a_3, a_4\}$

where each level has the following general definition:

- a<sub>0</sub> = no economic penalties, no operational penalties, no change in mission profile, and no fatalities,
- a<sub>1</sub> = economic penalties, no operational penalties, no change in mission profile, and no fatalities,
- a<sub>2</sub> = operational penalties, no change in mission profile, and no fatalities,
- a<sub>3</sub> = change in mission profile, and no fatalities,
- $a_A = fatalities.$

Thus, by accounting for the relative importance of various attributes, the number of relevant levels of accomplishment is reduced from 16 (the number of subsets of the set of 4 attributes) to 5. On the other hand, the information regarding relative worths is not essential, i.e., the evaluation could be carried out relative to a 16 level accomplishment set.

For this accomplishment set, we then developed a hierarchical model of the total system comprised of three levels:

Level 0: Mission Level

Level 1: Aircraft Functional Task Level

Level 2: Computer Level.

Construction of this model proceeded in a top-down manner (i.e., level  $0 \ge$  level  $1 \ge$  level 2) as generally discussed in earlier reports (see [3], pp. 81-82, for example). The subsections that follow describe this hierarchy, i.e., the models at each level and the interlevel translations between adjacent models.

3.3.1.2 Mission Level Model

The mission level model (level 0) describes the total system performance in terms closely related to the accomplishment set A.

Formally, this model is a single variable random process  $Z = X_h^0$  taking values in the state space

$$p^0 = \{0,1\}^4$$

where a state  $q = (q_1, q_2, q_3, q_4) \in Q^0$  is interpreted as follows:

••• ·	0	if the mission has no economic penalties
<sup>q</sup> 1 <sup>=</sup>	11	otherwise,
~ ~	(0	if the mission has no operational penalties
<sup>q</sup> <sub>2</sub> =	1	otherwise,
· ·	0	if the mission has no change in mission profile
<sup>q</sup> <sub>3</sub> =	11	otherwise,
	ſo	if the mission is safe
<sup>q</sup> <sub>4</sub> =	11	otherwise.

If  $\xi_i$  is the projection of  $Q^0$  onto its i<sup>th</sup> coordinate, we let  $z_i$  denote the random variable  $\xi_i Z$ , i.e.,

 $Z = (z_1, z_2, z_3, z_4).$ 

As a mnemonic aid, these variables are alternatively referred to as follows:

 $z_1 = ECONOMICS$  $z_2 = OPERATIONS$  $z_3 = PROFILE$  $z_4 = SAFETY.$ 

Because the level 0 model consists of a single random variable, the trajectory space  $U^0$  (see [3], p. 20) coincides with the state space, i.e.,

$$U^0 = Q^0 = \{0,1\}^4$$

Table 1 specifies the inverse of the interlevel translation  $\kappa_0$  or, what is the same, the partial capability function  $\gamma_0$  (see [3], p. 26). Because of the inability of computer\_output to denote subscripts, the accomplishment level indices are placed in parenthesis after the letter "a." For example,  $a_3$  is written a(3). This is similar to the method used in FORTRAN and other computer languages to specify array subscripts and should cause no confusion. The "\*" notation of Table 1 represents a "don't care" situation and signifies that any valid entry is acceptable.

## Table 1 Page 1 of 1

## LEVEL G TO PERFORMANCE LEVEL INTERLEVEL TRANSLATION

# (LEVEL O INVERSE PARTIAL CAPABILITY FUNCTION)

		• • • • • • • • • • • • • • • • • • • •
Performance Level	1	Level 0
	[ .	Trajectory Sets
		r i san ing i sa shekara shekara ta
	1 100	1 0   ECONOMICS
a (0) ( ee e e e e e e e e e e e e e e e e e	1	0 OPERATIONS
	P 42 4	O   PROFILE
	l	LOJ SAFETY
** The second se Second second sec	l and with	a de la compansión de la c La compansión de la compans La compansión de la compans
	l	
	1	T ECONOMICS
a (1)	1	OPERATIONS
* <b></b>	1	O PROFILE
		U SAPETI
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	1	
a (2)	1 · · ·	1 1 ODERATIONS
α (2)	1	I C I PROFILE
	1 · · · · · · · · · · · · · · · · · · ·	LOJ SAFETY
	•	G PRIMI
· · · · · · · · · · · · · · · · · · ·	•	
	1	+ ECONOMICS
a (3)	i .	*   OPECATIONS
$\mathbf{V}$	1	1 1 PROFILE
	Î.	L C J SAFETY
<ul> <li>A state of the sta</li></ul>	1	
• :	l'anna an	Т
	€	*   ECONOMICS
a (4)	1.000	*   OPERATIONS
· · · · · · · · · · · · · · · · · · ·	t de la composition	*   PROFILE
	1	L 1 J SAFETY

## 3.3.1.3 Aircraft Functional Task Level Model

To determine an appropriate model at the aircraft functional task level, we assume the following characteristics regarding the aircraft to be used in the mission. (See [7] for more details regarding these specific aircraft functions.)

> a) The aircraft has an Aircraft Integrated Data System (AIDS) which continuously executes in-flight analyses of various on-board data. This information is economically useful to the airline for assessing aircraft performance and for scheduling maintenance. Thus, loss of AIDS results in an economic setback to the air carrier.

b) The aircraft has two means of navigation. The first involves an inertial guidance system (INERTIAL) which will operate at any point regardless of latitude, while the second means involves an air data system (AIR DATA) along with two radio beacon systems: Very-High Frequency Omniranges (VOR) and Distance Measuring Equipment (DME). We assume that the signals generated by the VOR/DME systems will not be receivable by aircraft more than 250 nautical miles from a transmitting station, and in particular, more than 250 nautical miles from land. The AIR DATA function is required to support the VOR/DME function.

c) If the aircraft loses its inertial system before entering a region where it cannot receive VOR/DME signals, (especially an oceanic region on a transoceanic mission), the plane will return to its origin. We make the simplifying assumption that if the plane must make such a diversion, the plane returns safely to its origin with no further incidents. This assumption is made because the theory to support the use of multiple, state-dependent utilization periods has not yet been developed. Such a diversion is considered a change in mission profile.

d) If the aircraft loses its inertial system while out of range of VOR/DME, then the plane loses all navigational capability. Likewise, if the aircraft loses its INERTIAL system and its capability to analyze VOR/DME-AIR DATA information (i.e., either the VOR/DME function or the AIR DATA function), then the aircraft loses all navigational capability. Such a loss of navigation will be considered a change in mission profile. e) If the aircraft loses either its AIR DATA function or its VOR/DME function, then the loss is considered an operational penalty. Of course, if both functions fail, a change in mission profile may occur. (See d) above.)

f) The aircraft has an autoland system (AUTOLAND) which, if working, will land the plane in any weather. This system is used only in Category III weather. The AUTOLAND system requires the results of INERTIAL computations as well as AUTOLAND computations. If at the initiation of landing, the destination airport has Category III weather and the aircraft does not possess the AUTOLAND capability, then a diversion is made to another airport. Such a diversion is considered a change in mission profile.

• <del>•</del> .a 🚓, g) If at the initiation of landing, the destination airport has Category III weather, and the aircraft has the AUTOLAND capability, then loss of AUTOLAND during landing will cause the plane to crash, resulting in an unsafe mission.

h) The aircraft has active flutter control (ACTIVE FLUTTER CONTROL), attitude control (ATTITUDE CONTROL), and engine control (ENGINE CONTROL) functions, all of which are critical to the airworthiness of the plane. Loss of any one of these functions entails fatalities and, hence, an unsafe mission.

i) The onboard computer is involved actively in all aircraft functions mentioned above. Furthermore, the computer is involved in no other tasks.

Under the above assumptions, we have the following (worst case) conditions relating functional tasks to the mission variables  $z_1$ ,  $z_2$ ,  $z_3$ ,  $z_4$  discussed in the previous section:

	0	if	AIDS	works	for	the	entire mission
$z_1 = ECONOMICS -$	11	if	AIDS	fails	at	some	point in the
		mrs	STON				

0

 $z_2 = OPERATIONS =$ 

.

entire mission

if VOR/DME and AIR DATA both work for the

1 if VOR/DME or AIR DATA fail at some point in the mission,

- 0 if i) INERTIAL works through the initiation of landing and AUTOLAND works at the initiation of landing, or ii) INERTIAL works until the plane is near enough to its destination to receive VOR/DME and the weather at the initiation of landing is not Category III, or iii) INERTIAL works through the initiation of landing and the weather at the initiation of landing is not Category III,
- 1 if i)INERTIAL and either VOR/DME or AIR DATA fail when the plane is near its destination, or ii) INERTIAL fails when the plane is near its source, or iii) INERTIAL fails when the plane is out of range of VOR/DME signals, or iv) AUTOLAND fails at the initiation of landing and the weather at the initiation of landing is Category III,
- 0 if either i) AUTOMATIC FLUTTER CONTROL, ENGINE CONTROL, and ATTITUDE CONTROL work during the entire mission; INERTIAL works while the aircraft is close to -its source (until the plane is out of range of VOR/DME); and at the initiation of landing and one of the following is true: a) the weather is not Category III, or
  - b) the weather is Category III but either AUTOLAND or INERTIAL does not work, or
  - c) the weather is Category III, and both AUTOLAND and INERTIAL work through the conclusion of the landing,
  - or ii) AUTOMATIC FLUTTER CONTROL, ENGINE CONTROL, and ATTITUDE CONTROL work while the aircraft is close to its source (until the plane is out of range of VOR/DME), but INERTIAL does not work at some point during the same interval,
- 1 if either i) AUTOMATIC FLUTTER CONTROL, ENGINE CONTROL, or ATTITUDE CONTROL do not work at some point during the mission, or ii) at the initiation of landing, the weather is Category III, and AUTOLAND and INERTIAL work, but then during landing, either AUTOLAND or INERTIAL fail.

Hence, the model at the aircraft functional task level involves the following eight aircraft tasks along with a single

 $z_A = SAFETY =$ 

 $z_3 = PROFILE =$ 

#### environment variable:

AIDS VOR/DME AIR DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL WEATHER (environment).

Also, because of the considerations regarding the range of the VOR/DME and the initiation of landing, four phases are appropriate:

Phase 1 = Takeoff/cruise until VOR/DME out of range, Phase 2 = Cruise until VOR/DME in range again, Phase 3 = Cruise until landing is to be initiated, and Phase 4 = Landing,

where their descriptions are abbreviated as follows:

Phase 1 = Takeoff/Cruise A Phase 2 = Cruise B Phase 3 = Cruise C Phase 4 = Landing.

Graphically, the utilization period is decomposed as follows:



<u>,</u> .

Formally, the aircraft level model is a random process Y with four random variables:

$$Y = \{x_a^1, x_b^1, x_c^1, x_h^1\}$$

where a is the time at which Cruise A ends, b is the time at which Cruise B ends, c is the time at which Cruise C ends, and h is the time at which the landing ends (since the utilization period is [0,h]). The state space for each phase is

$$Q^1 = \{0,1\}^9$$

where a state  $q = (q_1, q_2, q_4, q_5, q_6, q_7, q_8, q_9)$  in  $Q^1$  is interpreted as follows:

	0	if AIDS works during the entire phase
q <sub>1</sub> =	1	if AIDS fails at some point during the phase,
	0	if VOR/DME works during the entire phase
<sup>q</sup> 2 <sup>=</sup>	1	if VOR/DME fails at some point during the phase,

~		0	if AIR DATA works during the entire phase
Ч <u>3</u>		1	if AIR DATA fails at some point during the phase,
q,	=	0	if INERTIAL works during the entire phase
-4		(1	if INERTIAL fails at some point during the phase,
~	-	0	if AUTOLAND works during the entire phase
<sup>q</sup> 5 =	11	if AUTOLAND fails at some point during the phase,	
-	_	( <sup>0</sup>	if ACTIVE FLUTTER CONTROL works during the entire phase
<sup>q</sup> 6	-	1	if ACTIVE FLUTTER CONTROL fails at some point during the phase,
		0	if ENGINE CONTROL works during the entire phase
9 <sub>7</sub>	H , ,		if ENGINE CONTROL fails at some point during the phase,
•	<b>-</b> ,	0	if ATTITUDE CONTROL works during the entire phase
<sup>д</sup> 8	-	ĺ	if ATTITUDE CONTROL fails at some point during the phase,
		1.	is one other than the initiation

Using the array representation discussed in the Third Semi-Annual Status Report [3], the process Y is written as a matrix of random variables

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$y_{11}$ $y_{12}$ $y_{13}$ $y_{14}$ AIDS	
Y <sub>21</sub> Y <sub>22</sub> Y <sub>23</sub> Y <sub>24</sub> AIR DATA	
Y <sub>31</sub> Y <sub>32</sub> Y <sub>33</sub> Y <sub>34</sub> VOR/DME	
Y <sub>41</sub> Y <sub>42</sub> Y <sub>43</sub> Y <sub>44</sub> INERTIAL	
= $y_{51} y_{52} y_{53} y_{54}$ AUTOLAND	
Y <sub>61</sub> Y <sub>62</sub> Y <sub>63</sub> Y <sub>64</sub> ACTIVE FLUTTER C	ONTROL
Y71 Y72 Y73 Y74 ENGINE CONTROL	
Y <sub>81</sub> Y <sub>82</sub> Y <sub>83</sub> Y <sub>84</sub> ATTITUDE CONTROL	•
Y <sub>91</sub> Y <sub>92</sub> Y <sub>93</sub> Y <sub>94</sub> WEATHER.	e.

Y

Here  $y_{ij}$  is the i<sup>th</sup> coordinate of the j<sup>th</sup> variable in Y (e.g.,  $y_{23}$  is the AIR DATA coordinate of  $X_c^1$ ). In the discussion of Section 3.3.3, an alternate notation for  $y_{ij}$  will sometimes be employed: if I is the name of row i (as indicated given above), then  $y_{ij}$  will be written I(j), e.g.,  $y_{23}$  = AIR DATA (3). Accordingly, the trajectory space for the level 1 model is

 $U^{1} = \{0,1\}^{9} \times \{0,1\}^{9} \times \{0,1\}^{9} \times \{0,1\}^{9} \times \{0,1\}^{9}$  $= \{0,1\}^{36}$ 

whose elements are represented as  $9 \times 4$  matrices over  $\{0,1\}$ .

Using the above information, the translation between the mission level (level 0) and the aircraft functional task level (level 1) was formulated, i.e., the inverse  $\kappa_1^{-1}$  of the level 1 to level 0 interlevel translation  $\kappa_1: U^1 \neq U^0$  (see [3], p.24). Employing the method described in the previous report ([4],pp. 96-103)  $\kappa_1^{-1}(z)$  for some mission outcome z can then

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be expressed as the intersection of the component inverses  $(\xi_i \kappa_1)^{-1}$ , i.e.,

$$\kappa_{1}^{-1}(z) = (\xi_{1}\kappa_{1})^{-1}(z_{1}) \cap (\xi_{2}\kappa_{1})^{-1}(z_{2}) \cap (\xi_{3}\kappa_{1})^{-1}(z_{3}) \cap (\xi_{4}\kappa_{1})^{-1}(z_{4})$$

=  $(\xi_{\text{ECONOMICS}^{\kappa_1}})^{-1}$  (ECONOMICS)  $\cap (\xi_{\text{OPERATIONS}^{\kappa_1}})^{-1}$  (OPERATIONS)  $\cap (\xi_{\text{PROFILE}^{\kappa_1}})^{-1}$  (PROFILE)  $\cap (\xi_{\text{SAFETY}^{\kappa_1}})^{-1}$  (SAFETY)

where

$$\begin{bmatrix} z_1 \\ z_2 \\ z_3 \\ z_4 \end{bmatrix} = \begin{bmatrix} \text{ECONOMICS} \\ \text{OPERATIONS} \\ \text{PROFILE} \\ \text{SAFETY} \end{bmatrix}$$

is some mission level trajectory.

Table 2 shows the component inverses  $(\xi_{i}\kappa_{i})^{-1}$ (i=1,2,3,4) of the interlevel translation  $\kappa_{1}$ . The first column of the table names the coordinate being considered, that is, one of ECONOMICS  $(z_{1})$ , OPERATIONS  $(z_{2})$ , PROFILE  $(z_{3})$ , or SAFETY  $(z_{4})$ , while the second column gives the value of that coordinate (either 0 or 1). The third column presents a level 1 trajectory set that maps into the given level 0 coordinate value. For coordinate i and value v the union of all the indicated Cartesian trajectory sets is the set  $(\xi_{i}\kappa_{1})^{-1}(v)$ . Thus, for example, the trajectory set which corresponds to SAFETY=0, i.e., the set  $(\xi_{3}\kappa_{1})^{-1}(0)$ , is

COORDINATE INVERSES OF Table 2 LEVEL 2 TO LEVEL 1 TRANSLATION Page 1 of 10 LEVEL 1 LEVEL O INAME CJORDINALE | VALUE TRAJECTORY SEIS 6..... : F 00001 AIDS \* \* \* | VOR/DHE \* \* \* 1 \* \* AIS DATA \* 44 \* \* INERTIAL ECONOMICS 0 ¥. ¢ \* AUTOLAND A \* \* ACTIVE FLUTTER CONTROL # # ] ENGINE CONTROL \* \* \* j \* ATTIIUDE CONTROL LEEXEJ WEATHER 5 ALDS \* 1 VOR/DME . \* 1 ALR DATA \* \* ] \* \* \* INERTIAL ECONOMICS 1 ¢ AUTCLAND b \* ACTIVE FLUTIER CONTROL ENGINE CONTROL ATTITUDE CONTROL Ì **WEATHER** AICS 0 1 \* \* \* | VOR/DME \* × 本 AIR DATA \* \* \* \* INERTIAL 本 \* \* ELONOMICS | 1 AUTOLAND \* С \* 1 ACTIVE FLUTTER CONTROL \* \* \* ENGINE CONTROL \* \* \* \*\* \* ATTITUDE CONTROL 2 2 WEATHER 2.1 AIDS 0 Ο - 1 \* \* 1 VOR/DME \* ATE DATA \* 1 \* 1 INEBIIAL \* - i\_\_\_\_\_\_ ECONOMICS 1 \* 1 AUICLAND đ 2 Ł ACTIVE FLUTTER CONTROL \* \* \* ENGINE CONTRCL \* \* \* \* ATTITUDE CONTROL LZETEI WEATHER Ť |Column 1: Phase 1 = Takeoff/Cruise A |Column 2: Phase 2 = Cruise B Column 3: Phase  $3 = \text{Cruise } C^{2}$ (C) ... 4: Phase 4 = Landing

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# COOLDINATE INVERSES OF Table 2 LEVEL 2 TO LEVEL 1 TRANSLATION Page 2 of 10

LEVEL (	)	LEVEL 1 TRAJECTORY SETS	NAME
ECONOMICS		0       0       1       AIDS         * * * *       VOR/DME         * * * *       AIE DATA         * * * *       AIE DATA         * * * *       INTERTIAL         * * * *       AUTOLAND         * * * *       ACTIVE FLUTTER CONTROL         * * * *       ENGINE CONTROL         * * * *       ATTITUDE CONTROL         * * * *       ATTITUDE CONTROL         * * * *       WEATHER	
UPERATIONS	0	* * * * * * * * * * * * * * * * * * *	
OP LEAFLONS	1	I       # * * * I       AIDS         I       1 * * * I       VOR/DME         I       # * * I       AIR DATA         I       * * * I       INERTIAL         I       # * * I       INERTIAL         I       # * * I       AUTOLAND         I       * * * I       ACTIVE FLUTTER CONTROL         I       * * * I       ENGINE CONTROL         I       * * * I       ATTITUDE CONTROL         I       * * * I       ATTITUDE CONTROL         I       # * * I       WEATHER	
C2 ERATIGINA		* * * *       AICS         0 1 * *       VCE/DME         * * * *       AIR DATA         * * * *       INERTIAL         * * * *       INERTIAL         * * * *       AUTOLAND         * * * *       ACTIVE FLUTTER CONTROL         * * * *       ACTIVE FLUTTER CONTROL         * * * *       ATTITUDE CONTROL	
		Column 1: Phase 1 = Takeoff/Cruise A Column 2: Phase 2 = Cruise B Column 3: Phase 3 = Cruise C Column 4: Fhase 4 = Landing	

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COORDINATE INVERSES OF LEVEL 2 TO LEVEL 1 TRANSLATION Table 2 Page 3 of 10

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LEVEL	0(	LEVEL 1	NAME
COORDINATE L	VALUE	TRAJECTORY SEIS	
OP ERAFLONS		Image: style="text-align: center;">	
OD FF VLION2		$*$ $*$ $*$ $*$ $*$ $AIDS$ $0$ $0$ $1$ $VOF/DME$ $*$ $*$ $*$ $AIR$ $DATA$ $*$ $*$ $*$ $AIR$ $DATA$ $*$ $*$ $*$ $INERTIAL$ $\notin$ $\#$ $*$ $AUTOLANE$ $*$ $*$ $*$ $ACTIVE$ $FLUTTER$ $*$ $*$ $*$ $ACTIVE$ $*$ $*$ $*$ $ENGINE$ $*$ $*$ $*$ $ATTITUDE$ $4$ $#$ $4$ $4$ $4$ $4$ $4$ $4$ $4$ $4$ $4$	
CP ERATIONS		<pre>* * * * AIES C 0 0 0 VOR/DME 1 * * AIE DATA * * * * INERTIAL 2 &amp; * * AUTCLAND * * * * ACTIVE FLUTTER CONTROL * * * * ENGINE CONTROL * * * * ACTIVUE CONTROL * * * * HATTITUDE CONTROL # * * * HATTITUDE CONTROL # * * * HATTITUDE CONTROL # * * * HATTITUDE CONTROL</pre>	
CP EKATIONS		* * * *       AIES         0 C U U       VCF/DME         0 1 * *       AIR DATA         * * * *       INERTIAL         2 2 * *       AUTOLAND         * * * *       ACTIVE FLUTTER COMTROL         * * * *       ENGINE CONTROL         * * * *       ATTITUDE-CONTROL         2 2 * 2       WEATHER	
CEERATIONS	1	$\begin{bmatrix} * & * & * & \\ & AIES \\ 0 & 0 & 0 &   VOR/DME \\ 0 & C & 1 &   AIE DATA \\ & & & & \\ & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & & & \\ & & & & & & & \\ & & & & & & \\ & & & & & & & \\ & & & $	
		Column 1: Phase 1 = Takcoff/Cruise A Column 2: Phase 2 = Cruise B Column J: Phase 3 = Cruise C 	

ICoLumn 1 ICoLumn 2	: Phase : Phase	$\overline{1} = 1$ ake 2 = Crui	off/C se B	ruise A
$\begin{array}{c} 1 \text{Column} & 3 \\ 1 & 1 \text{ and } 4 \end{array}$	: Phase : Phase	3 = Crui 4 = Land	se C. ling	

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LEVEL Ö CORDINAFE   VALUE	I IEVEL 1 TRAJECTORY SETS	NAME
UPERATIONS 1	* * * *       AIDS         0 0 0 0       VOR/DME         0 0 0 1       AIR DATA         * * * *       INERTIAL         # # * *       AUTOLAND         * * * *       ACTIVE FLUTTER CONTROL         * * * *       ENGINE CONTROL         * * * *       ATTITUDE CONTROL         * * * *       NEATHER	1
MISSION PROFILE 0	* * * *         AICS           * * * *         VOE/DME           * * * *         AIR DATA           0 0 0 *         INERTIAL           \$\$\nothermid{\$\nohermid{\$\nohermid{\$\nohermid{\$\nothermid{\$\nohermid{\$\nothermid{\$\	
AISSION PEOFILE C	# * * * *       AICS         * * 0 *       VCR/DME         * * C *       AIE DATA         G 0 1 *       INFR'IAL         Z Z * *       AUTOLAND         * * * *       ACTIVE FLUTTER CONTROL         * * * *       ENGINE CONTFOL         * * * *       ATIITUDE CONTROL         2 Z 0 Z -       WEATHER	B
MISSICH PROFILE O	* * * * *       Alcs         * * * *       VOF/DME         * * * *       Alr DATA         0 0 0 *       INEFTIAL         2 2 1 *       AUTOLAND         * * * *       ACTIVE FLUTTER CONTROL         * * * *       ENGINE CONTROL         * * * *       ATTITUDE CONTROL         * * * *       ATTITUDE CONTROL	C

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福田市を通行をなったいというとういうない。

COORDINATE INVERSES OF LEVEL 2 TO LEVEL 1 TRANSLATION Table 2 Page 4 of 10

LEVEL O CORDINATE I VALUE	LEVEL 1 TRAJECTORY SETS	INAME
		1
	1 + x + 1 + 1 + 1 + 1 + 1 = 0	
and a start of the start of th	$1001 \times 1000$	
SSIGN PROFILE 1		i a
	I I * * * * I ACTIVE FLUTTER CONTROL	1
	* * * +   ENGINE CONTROL	1
	* * * *   ATTITUDE CONTROL	
	$\mathbf{L} \in \mathcal{L} \times \mathcal{L} \times \mathcal{L} = \mathbf{W} = $	
	1 * * * * AIDS	
	+ + 1 +   VOR/DME	
	I I + + 0 + I AIR DATA	1
ONTAL AAANT73 4	I U U I * I INERTIAL	
22TON SKORTTE 1		l e
	1 1 * * * * 1 FNCINE CONTROL	
	* * * *   ATTITUDE CONTROL	
	J L Z Z * Z J WEATHER	
	- 1	
	* * * +   AIR DATA	1
	1 1 * * * INERTIAL	
SSION PROFILE 1	I I Z Z * * I AUTOLAND	j f
	I I * * * * ACTIVE FLUTTER CONTROL	
	* * * *   ENGINE CONTROL	1
	I I * * * * I ATTITUDE CONTROL I L C C * C J WEATHER	
		i
	+ + + +   AT DS	
에 가장 사람은 것은 것이 가장에 가지 않는다. 같은 사람의 것이라는 것은 것이라는 것이라.		୍ୟ କାର୍ଯ୍ୟ
	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	
SSION PROFILE 1		Ιa
	ACTIVE FLUTTER CONTROL	j - J
	+ * * +   ENGINE CONTECL	
	* * * *   ATTITUDE CONTROL	1
	Į č ¢ ≉ ¢ ⊐ ₩EATHER	
	i + + + + i AIR DAIA	1
	O G O *   INERTIAL	i
SSICK PROFILE 1	I I F F I * I AUTOEAND	l h
	* * * *   ACTIVE FLUTTER CONTROL	Î.
	I I * * * + ENGINE CONTROL	
	* * * *   ATTITIDE CONTROL	
	I - F 5-1 F - WEATHER	
	Column 1: Phase 1 = Takeoff/Cruise A	
	(Column 2: Phase 2 = Cruise B	
	JULLING 3: Phase 3 = Cruise C	
and a second second A second secon	医马克马马马克 化化化合物 网络神经科学 化二甲基甲基甲基甲基甲基甲基甲基甲基甲基甲基甲基甲基甲基甲基甲基甲基甲基甲基甲基	ana 👖 a China Shire

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COORDINATE INVERSES OF LEVEL 2 TO LEVEL 1 TRANSLATION

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Table 2 Page 6 of 10

LEVEL O	LEVEL 1
NISSION PROFILE 1	$\begin{bmatrix} * & * & * & * & \\ & * & * & * & \\ & * & *$
SAFETYO	* * * *         AICS         * * * *         VOR/DME         * * * *         AIE DATA         0 * * *         INERTIAL         2 2 * *         AUTCLAND         0 0 0 0       ACTIVE FLUTIER CONTROL         0 0 0 0       ACTIVE FLUTIER CONTROL         0 0 0 0       ACTIVE CONTROL         0 0 0 0       ATTITUDE CONTROL         2 2 0 2       WEATHER
SAFETY 0	* * * *       AIES         * * * *       VOR/DME         * * * *       AIR DATA         0 * * *       INERTIAL         2 ± 1 *       AUTOLAND         0 0 0 0       ACTIVE FLUTIER CONTROL         3 0 0 0       ENGINE CONTEOL         0 0 0 0       ATTITUDE CONTROL
SAFETY C	* * * *       AIES         * * * *       VOR/DME         * * * *       AIF DATA         0 * 1 *       INFRTIAL         \$\nothermodell' \varepsilon 0 *       AUTCLAND         0 0 0 0       ACTIVE FLUTTER CONTROL         0 0 0 0       ENGINE CONTROL         0 0 0 0       ATTITUDE CONTROL         0 0 0 0       ATTITUDE CONTROL         \$\varepsilon 2 \$\varepsilon 1 \$
	ORIGINAL PAGE IS OF POOR QUALITY
	[Column 1: Thase 1 = Takeoff/Cruise A         [Column 2: Phase 2 = Cruise B         [Column 3: Phase 3 = Cruise C         [Column 4: Phase 4 = Landing

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COORDINATE INVERSES OF Table 2 LEVEL 2 TO LEVEL 1 TRANSLATION Page 7 of 10

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LEVE	L 0	I EVEL 1	INAME
COORDINATE_	I_VALUE	TFAJECTORY SETS	_ <b>_</b>
SAFELY	0	* $*$	
SA FEPY	Ø	I       *       *       *       AIES         I       *       *       *       VOR/DME         I       *       *       *       INERTIAL         I       *       *       *       INERTIAL         I       *       *       INERTIAL         I       *       *       INERTIAL         I       *       *       INTOLAND         I       I       *       *       ACTIVE FLUTTER CONTROL         I       I       *       *       INGINE CONTROL         I       I       I       INGINE CONTROL       INGINE CONTROL         I       I       INGINE CONTROL       INGINE CONTROL       INGINE CONTROL         I       I       INGINE CONTROL       INGINE CONTROL       INGINE CONTROL         I       I       INGINE CONTROL       INGINE CONTROL       INGINE CONTROL         I       I	i i i i i i i i i i i i i i i i i i i
SA YEIY	1	I       * * * * I       AICS         I       * * * * I       VOF/DME         I       * * * * I       AIR DATA         I       * * * * I       AUTOLAND         I       * * * I       AUTOLAND         I       * * * I       ACTIVE FLUTTER CONTROL         I       * * * I       ENGINE CONTROL         I       * * * I       AITITUDE CONTROL         I       * * & J       AITITUDE CONTROL         I       # & & J       HEATHER	
SAFEIX		[ * * * * * ]       AIES         [ * * * * ]       VOR/DME         [ * * * * ]       AIE DATA         [ # * * * ]       AIE TAL         [ ] 0 * * * ]       AUTCLAND         [ ] 0 * * * ]       ACTIVE FLUTTER CONTROL         [ ] 1 * * * ]       ENGINE CONT HER         [ ] 2 # # ]       WEATHER	
		Column 1: Phase 1 = Takeoff/Cruise A	

Phase 3 = Cruise C Fhase 4 = Landing olume u:

CORDINATE INVERSES OF LEVEL 2 TO LEVEL 1 TRANSLATION

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Table 2 Page 8 of 10

LEVEL O	LEVEL 1	INAME
COORDINATE I VALUE	<u>TRAJECIORY</u> SEIS	.L
SAFETY 1	* * * *       AICS         * * * *       VOR/DME         * * * *       AIR DATA         * * * *       INERTIAL         # * * *       INERTIAL         # * * *       AUTOLAND         # * *       ACTIVE PLUTTER CONTROL         # * *       ENGINE CONTROL         # * *       ATTITUDE CONTROL         # * *       ATTITUDE CONTROL         # * *       ATTITUDE CONTROL	
SAFETY 1	* * * * *AICS $* * * * *$ VCE/DME $* * * * *$ AIR DATA $0 * * * *$ INERTIAL $2 & 2 * * *$ AUTOLAND $1 + * * * *$ ACTIVE FLUTTER CONTROL $0 * * * *$ ENGINE CONTROL $0 * * * *$ ENGINE CONTROL $0 * * * * * * * * * * * * * * * * * * *$	
SAFETY 1	<pre></pre>	
SAFEIY i	<ul> <li>* * * * *</li> <li>AICS</li> <li>* * * *</li> <li>VOR/DME</li> <li>* * * *</li> <li>AIR DATA</li> <li>0 * * *</li> <li>INERTIAL</li> <li>0 * * *</li> <li>INERTIAL</li> <li>0 * *</li> <li>AUTOLAND</li> <li>0 0 * *</li> <li>AUTOLAND</li> <li>0 0 * *</li> <li>AUTOLAND</li> <li>0 0 * *</li> <li>ENGINE CONTROL</li> <li>0 1 * *</li> <li>ATTITUDE CONTROL</li> <li>2 \$\varnotheta * \$\varnotheta\$</li> <li>WEATHER</li> </ul>	
ORIGINAL QUALLY OF POOR QUALLY SAFETY 1	<ul> <li></li></ul>	
	IColuan 1:Phase 1 = Takeoff/Cruise AIColuan 2:Phase 2 = Cruise BIColuan 3:Phase 3 = Cruise CIColuan 4:Phase 4 = Landing	

CODEDINATE INVERSES OF LEVEL 2 TO LEVEL 1 TRANSLATION Table 2 Page 9 of 10

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LEVE	LÜ	LEVEL 1	NAM B.
CUULDINATE_	L_VALUE	TRAJECTORY SETS	
SAFELY		$* * * *$ AIES $* * * *$ VOE/DME $* * * *$ AIR DATA $0 * * *$ INERTIAL $\ell \notin * *$ AUTOLAND $0 0 0 *$ ACTIVE FLUTTER CONTROL $0 0 0 *$ ACTIVE FLUTTER CONTROL $0 0 0 * *$ ATTITUDE CONTROL $0 0 0 * *$ ATTITUDE CONTROL $\ell \notin * \notin$ WEATHER	
SAFETY		* $*$	
SAFEIY	<b>1</b> - 5	# * * * *       AIES         * * * *       VOR/DME         * * * *       AIR DATA         0 * * *       INERTIAL         2 g * *       AUTOLAND         0 0 G 1       ACTIVE FLUTTER CONTROL         0 0 0 *       ENGINE CONTROL         0 0 0 *       ENGINE CONTROL         0 0 0 *       ATTITUDE CONTROL         2 g * g J       WEATHER	O
SAFELY -	1	# * * *       AIES         * * * *       VOR/DME         # * * *       AIR DATA         9 * * *       INERTIAL         \$\varnothingsquare       AUTOLAND         \$\varnohingsquare       AUTOLAND      <	<b>P</b>
SAPETY	1	* * * * *       AIES           * * * *       VOR/DME           * * * *       AIR DATA           0 * * *       INERTIAL           2 2 * *       AUTOLAND           0 0 0       ACTIVE FLUTTER CONTROL           0 0 0       ENGINE CONTROL           0 0 0       INTITUDE CONTROL           2 2 * 2       WEATHER	<b>B</b>
		1 1 Dlumn 1: Phase 1 = Takeoff/Cruise A 1 Dlum 2: Phase 2 = Cruise B 1 mh 3: Phase 3 = Cruise C . Jn 4: Phase 4 = Landing	

COORDINATE INVERSES OF TAL EVEL 2 TO LEVEL 1 TRANSLATION PAGE

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	LEVEL 2 TO LEVEL 1 THANSLATION PAGEIO	OF IU
LEVEL Ú CUORDINATE I VALUE	LEVEL 1 TRAJECTORY SETS	INAME
SAFEFY 1	$*$ $*$ $*$ $*$ $*$ $*$ $*$ $*$ $*$ $*$ $VCF/DME$ $*$ $*$ $*$ $*$ $VCF/DME$ $*$ $*$ $*$ $ATR CATA$ $G$ $*$ $*$ $INERTIAL$ $\neq$ $\varphi$ $0$ $1$ $AUTOLAND$ $O$ $O$ $O$ $ACTIVE$ $FLUTTER$ $O$ $O$ $O$ $O$ $ENGINE$ $CONTROL$ $O$ $O$ $O$ $O$ $ATTITUDE$ $CONTROL$ $\downarrow$ $\downarrow$ $\downarrow$ $\downarrow$ $WEATHER$	
SAFETY !	* * * *         AIES         * * * *         VOE/DME         * * * *         AIR DATA         0 * 0 1         INFRIIAL         2 ¢ 0 0         AUIOLAND         0 0 0 0         ACTIVE FLUTTER CONTROL         0 0 0 0         ENGINE CONTROL         0 0 0 0         ENGINE CONTROL         0 0 0 0         ATTITUDE CONTROL         0 0 0 0         ATTITUDE CONTROL         0 0 0 0         ATTITUDE CONTROL	
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ICDiumn 1: Phase 1 = Takeoff/Cruise A
ICDiumn 2: Phase 2 = Cruise B
ICDiumn 3: Phase 3 = Cruise C
Iumn 4: Phase 4 = Landing

AIDS VOR/DME AIR DATA INERTIAL ¢ \* \* 0 0 0 ¢ 0 AUTOLAND ACTIVE FLUTTER CONTROL ENGINE CONTROL 0 ATTITUDE CONTROL WEATHER AIDS VOR/DME AIR DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL WEATHER .

Finally, the fourth (rightmost) column of the table assigns a single letter name to each level 1 trajectory set; capital letters denote trajectory sets corresponding to coordinate values of 1, while lowercase letters denote trajectory sets associated with coordinate values of 0. Sets are referred to by these names in a later table (Table 3). Thus  $(\xi_3 \kappa_1)^{-1}$  (0) illustrated above is abbreviated

A U B U C U D U E. Thus, any aircraft level trajectory which appears in the above set results in a safe mission, and conversely, if a trajectory does not appear in the above set, then the corresponding mission is unsafe.

The next step (in the algorithm for determining  $\gamma^{-1}$ ) is to determine the inverse  $\gamma_1^{-1}$  of the level 1 based capability function  $\gamma_1$  (see [3], p. 26), where, for each level a in the accomplishment set

$$\gamma_{1}^{-1}(a) = \bigcup_{\substack{u \in \gamma_{0}^{-1}(a)}} \kappa_{1}^{-1}(u)$$

(In general, the determination of  $\gamma_1^{-1}$  involves "basic variables" as well as "composite variables"; see [3], p. 26. However, in the above case, the only variables at level 0 are composite, and hence they need not be carried down to level 1.) In order to manipulate sets of trajectories (and particularly Cartesian sets), the above formula can be generalized as follows. Suppose that  $\gamma_0^{-1}$  (a) is decomposed into a union of Cartesian sets  $U_1, U_2, \ldots, U_m$ . Then, from the above formula, it follows that

$$\gamma_1^{-1}(a) = \bigcup_{k=1}^{m} \kappa_1^{-1}(\underline{U}_k) \cdot (3.3.1)$$

Moreover, since  $U_k$  is Cartesian, membership of a trajectory u in  $U_k$  is uniquely determined by its coordinate memberships, that is,

if and only if, for all coordinates i, 
$$\xi_i(u) \in \xi_i(U_k)$$
. This  
important property says that Cartesian sets of trajectories can  
be manipulated in a manner similar to that of individual  
trajectories. In particular, if C is the set of coordinate  
indices of  $U^0$ , then

$$\epsilon^{-1}_{1}(\mathbf{U}_{k}) = \bigcap_{k=1}^{k} \left( \frac{\xi_{i} \kappa_{i}}{2} \right)^{-1} \left( \xi_{i} \left( \mathbf{U}_{k} \right) \right). \quad (3.3.2)$$

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Applying these formulas to the computation in question, we note first that each  $\gamma_0^{-1}(a)$  is already Cartesian. (See Table 1.) Thus a decomposition of  $\gamma_0^{-1}(a)$  into Cartesian sets is trivial, i.e.,  $\gamma_0^{-1}(a) = U_1$  and, by equation (3.3.1), we have

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$$\gamma_1^{-1}(a) = \kappa_1^{-1}(U_1).$$

Next, we note that C={1,2,3,4} and hence, by equation(3.3.2),

$$\gamma_{1}^{-1}(a) = \bigcap_{i=1}^{4} (\xi_{i} \kappa_{1})^{-1} (\xi_{i} (U_{1})). \quad (3.3.3)$$

The values of the intersected terms on the right are determined using Table 2 such that each term is expressed as a union of Cartesian sets. (Note that if  $\xi_i(U_1) = * = \xi_i(U^0)$  (an arbitrary value) or if  $\xi_i(U_1) = \notin$  (the i<sup>th</sup> coordinate of  $U^0$ is a constant) then the term  $(\xi_i \kappa_1)^{-1}(\xi_i(U_1))$  can be ignored, since it is equal to the whole level 1 trajectory space  $U^1$ .) Finally, these unions are intersected according to (3.3.3), the result being an expression of  $\gamma_1^{-1}$  (a) as a union of level 1 Cartesian trajectory sets. These resulting sets are displayed in Table 3. To illustrate this computation and to aid the interpretation of Table 3, consider the following example. <u>Example</u>

Suppose a=a0. Then, by row a(0) of Table 1,

$$\gamma^{-1}(a_0) = U_1 = \begin{bmatrix} 0\\0\\0\\0\end{bmatrix} \begin{bmatrix} \text{ECONOMICS}\\\text{OPERATION}\\\text{PROFILE}\\\text{SAFETY}.$$

 $\xi_{1}(U_{1}) = 0,$ 

 $\xi_{2}(U_{1}) = 0,$  $\xi_{3}(U_{1}) = 0,$ 

 $\xi_{3}(U_{1}) = 0,$ 

Thus,

where the correspondence between coordinate indices and coordinate names. ' Table 2) is:

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CCOMPLISHMENT	LEVEL	1 FRCEUCT TERMS		RESULTING
LCVEL	ECONOMICS   OPERA	TICNS   PROFILE	SAFETY	
ά (ΰ)	A			I       0       0       0       AIDS         I       0       0       0       VCR/DNE         I       0       0       0       AIR DATA         I       0       0       0       AIR DATA         I       0       0       0       INERTIAL         I       I       0       0       0       ACTIVE FLUTTER CONTROL         I       0       0       0       ENGINE CONTROL       INTITUDE CONTROL         I       0       0       0       ATTITUDE CONTROL       INTITUDE CONTROL
يت (0) ۳ (0)		<b>X</b>	B C	Ø (NULL ARKAY) Ø (NOLL ARKAY)
± (0) ± (0)			0	I       0       0       0       AIDS         I       0       0       0       VOE/DRE         I       0       0       0       AIR DATA         I       0       0       0       INERTIAL         I       2       0       0       INERTIAL         I       2       0       0       AUTOLAND         I       0       0       0       ACTIVE_PLUTTER CONTROL         I       0       0       0       ENGINE CONTROL         I       0       0       INTITUDE CONTROL         I       2       VEATHER       VEATHER         I       I       I       I
à (0)		<b>B</b>		I       0       0       0       AIDS         I       0       0       0       VOR/DME         I       0       0       0       AID S         I       0       0       0       AID S         I       0       0       0       AID S         I       0       0       0       AIT BATA         I       0       0       1       IWERTIAL         I       I       0       0       0       ACTIVE PLUTTER CONTROL         I       0       0       0       ACTIVE PLUTTER CONTROL         I       0       0       0       ATTITUDE CONTROL
4 (0) 4 (0)	A A	19 13 13	B C	Image: Second
a (0)		B	8	( AULL ARBAL) ( HULL ARRAY) ( 0 0 0 0 1 AIDS 1 0 0 0 0 1 VOR/DHE
4 (0)	Δ	¢		$ \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} $ AIR DATA $ \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} $ AUTOLAND $ \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} $ ACTIVE FLUTTEB CONTROL $ \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} $ ATTITUDE CONTROL $ \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} $ ATTITUDE CONTROL $ \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} $ ATTITUDE CONTROL $ \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} $ ATTITUDE CONTROL $ \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} $ ATTITUDE CONTROL $ \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} $ ATTITUDE CONTROL
				n an an an Anna an Ann An Anna an Anna

						• • • • •	
	Lumn 1:	Phase 1	= Takeoff/Cruise	A   Names a	re defined in	For each row, the	resultant
Col	una 2:	Phase 2	= Cruise B	I Table 2	2	level 1 trajectory	set is
201	una 3:	Phase 3	= Cruise C			the intersection o	f the sets
	lunn 4.	Phase 4	= Landing			named in Column 2.	
							and the second

Table 3 Page 2 of 22

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ACCONFLISTMENT	1	EVEL I ERC	CUCT TERMS	BESULTING	
	F.CONUNICS	OPERATIONS	PROFILE	SAFETY	
a (0) 1 (0) a (0) a (0) u (0)	A A A A	A A A A A	C C C C C C C C C C C C C C C C C C C	B C D B	Ø (NULL ARRAY) Ø (NULL ARRAY) Ø (NULL ARRAY) Ø (NULL ARRAY) Ø (NULL ARRAY)
a (1) s a (1) a (1) a (1)		<b>X</b>		B C	I       + + +       AIDS         I       0       0       VOE/DHE         I       0       0       AID DATA         I       0       0       AIE DATA         I       0       0       INERTIAL         I       2       0       INTOLAND         I       0       0       INTITUDE CONTROL         I       0       0       INTITUDE CONTROL         I       0       1       INTITUDE CONTROL         I </td
a (1) a (1)	b b	•		D	1       •••       AIDS         1       0       0       VOR/DNE         0       0       0       AIR DATA         0       0       0       INE DATA </td
a (1) . a (1) . a (1)	b		B B B	A B C	1 * * *       AIDS         1 0 0 0 0       VOR/DNE         1 0 0 0 0       AIE DATA         0 0 1 *       INERTIAL         1 € € * *       AUTOLAND         1 0 0 0 0       ACTIVE PLUTTER CONTROL         1 0 0 0 0       ACTIVE PLUTTER CONTROL         1 0 0 0 0       ACTIVE PLUTTER CONTROL         1 0 0 0 0       ATTITUDE CONTROL         1 0 0 0 0       ATTITUDE CONTROL         1 0 0 0 0       ATTITUDE CONTROL         9       (NULL ARRAY)         9       (NULL ARRAY)
1(1)	D D		B B	D 1 E	(NULL ARBAY) (NULL ARBAY)

 Column 1: Phase 1 = Takeoff/Cruise A | Names are defined in
 | Por each row, the resultant

 Column 2: Phase 2 = Cruise D
 | Table 2.
 | level 1 trajectory set is

 Column 3: Phase 3 = Cruise C
 | the intersection of the sets

 Column 4: Phase 4 = Landing
 | not column 2.

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 $\{ f_i \}_{i \in I}$ 

Table 3 Page 3 of 22

LEVEL		EVEL I PACD	LEVEL 1 TRAJECTORY SETS		
المحية المحاج عرفي فالمحاج المحاج المحاجة	ECORONICS I	OPERATIONS 1	PROFILE 1	SAPETY	
					1 * * * AIDS
		김 영화 영화 영화			I O O O O I VOR/DNE
					I O O O I AIB DATA
	[ 문양] 문양 문양 문양				I 0 0 0 + I INERTIAL
a (1)	l D	<b>A</b>	C	4	I E E T #   AUTOLAND
					I I U U U U I - ACTIVE FLUTTER CONTROL
					L L L O L J VEATHER
a(1)	Ъ	1	С	B :	Ø (NULL ARRAY)
a (1)	b	λ.	C	C	(NULL ABRAY)
a (1)	b ·	λ.	C	D	(NULL ARRAY)
a (1)	í b	A	С	8	(NULL ARDAX)
성실 것은 것 같아.	[일] 김 영영의				비 : 김 : 영상 : 김 : 영상 : 김 : 김 : 김 : 김 : 김 : 김 : 김 : 김 : 김 :
		방송 동안 같이 다.			0 1 · AIDS
					I I U U U U VOR/DHE
					L L O O O J ALE DALA
4/13					$1 \in \mathcal{C} = 1 + 1 = 1 = 1 = 1 = 1 = 1 = 1 = 1 = 1$
					1 0 0 0 0 1 ACTIVE PLUTTER CONTROL
					0000 ENGINE CONTROL
					1 0 0 0 0 1 ATTITUDE CONTROL
					LEEOEJ BEATHER
a (1) 🔰 🕴	C	1	λ	B	9 (NULL ARREY)
з (1)	C		<b>A</b>	C	(NULL ARRAY)
	방금 가격 경험 같이?				
					I O O O I ATR DATA
			승규는 것이 같아요.		I O O O I INERTIAL
a (1)	c	A	A	<b>b</b> 1	I C C O I AUTOLAND
					0 0 0 0   ACTIVE FLUTTER CONTROL
				: - 1	1 0 0 0 0   ENGINE CONTROL
		경험 관련을 가다		요즘 가지 한 것이!	1 0 0 0 0 1 ATTITUDE CONTROL
					LEEIEJ WEATHER
a(1)	C		•	8	Ø (NULL ARRAY)
		말 좋아 있는 것을 같다.			LOODI TORIDAR
	철학 이 것 같은 것 같은 것 같은 것 같이 많이 많이 많이 했다.				I O O O I AIR DATA
					1 0 0 1 *   INERTIAL
a (1)	C	A	B	λ Ι	I K K * *   AUTOLAND
	[19] 김 사람은	에 물 같은 것 같은 것 같은 것 집 같은 것 같은 것 같은 것			1 0 0 0 0 1 ACTIVE FLUTTER CONTROL
					1 0 0 0 0   ENGINE CONTROL
		전 가는 말을 갔다.		1	OOOO ATTITUDE CONTROL
					F F O F J WEATHER
Lunn 1: Phase	e 1 = Takeoff/C	ruise A   Na	mes are defi	ned in 1	Por each row, the resultant
Lumn 2: Phase	2 = Cruise B	- i ra	DTG 7-	아이는 아이 아이 있는 것을 물었다.	Level 1 trajectory set is
LUDI J: PIASE	s = crutse C				the intersection of the sets

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LCOAPLISHMENT		EVEL 1 FRO	JEUCT TERMS		RESULTING LEVEL 1 TRAJECTORY SETS
ا د د ۲ ۲ ۵ د . د د د د د د د د د د د د د د	ECONOMISS I	OPER ATIONS	PROPILE	SAPETY	
a (1)	Ċ	λ	B	B	Ø (NULL ARRAY),
a (1) - 1	<b>c</b>		B	C	Ø (NULL ARRAY)
a (1)	C	λ.	B	D [	Ø (NULL ARRAY)
a (1)	c	<b>X</b>	B	8 1	Ø (NULL ABRAY)
	방송 물 물 같이 있다.			<b>.</b>	이는 말했는 것 못 물러 못 한 것이 있는 것 같은 것을 하는 것이 가지 않는 것이 없다.
철 물통 수 있는 것 같아요.				1	
		말 잘 하는 것 .		1	1 0 0 0 0 VOR/DRE
				1	I O O O I AIR DATA
					0 0 0 +   INERTIAL
a(1) 1	c	8	C	<b>L</b> [	I E E 1 * I AUTOLAND
					1 0 0 0 0 1 ACTIVE FLUTTER CONTROL
				<b>i</b>	0 0 0 0   ENGINE CONTROL
		요즘 같은 것은 것이다.		en de la companya de	0 0 0 0 1 ATTITUDE CONTROL
				i i	L C C J WEATHER
a (1)	с	Å	С	B (	Ø (NULL AREAY)
	c		C	C i	Ø (NULL ARRAY)
aini	С	8	С	DI	Ø (NULL ARBAY)
	č		c	B I	Ø (NULL APRAY)
		이 집에 관하는 것이 없다.			승규는 뒤에 가지 않는 것 같아. 이렇게 집에 가지 않는 것이 가지 않는 것이 없는 것이 없다. 것이 있는 것이 없는 것이 없다. 것이 없는 것이 없
		명칭 승규님이다.			1001 * 1 AIDS
	이 가슴 지수는 것이다.				0 0 0 0 VOB/DNE
	김 김 씨는 것 같아요.		이 같은 것 같은 것 같은	1 · · · · · · · · · · · · · · · · · · ·	I O O O I AIR DATA
					1000 + 1 INERTIAL
	Ъ	<b>ì</b> ,	8	а і	I F F + +   AUTOLAND
: 2012년 - 2013년 - 2017년					1 0 0 0 1 ACTIVE PLUTTER CONTROL
	상황 감독을 감독하는 것이라.				1 0 0 0 1 ENGINE CONTROL
				i i	I O O O I ATTITUDE CONTROL
	말 같은 것이 같은 것이다.	영화 영화가 나는		· · · · · · · · · · · · · · · · · · ·	LECOCJ WEATHER
a / 11	a	8	R	BI	Ø (NULL ABRAY)
a (1) j	a	λ	*	C i	Ø (NULL ABRAY)
생활 사람이는 영지 않는	가 별 이 나라 가장 가장은 것이다. 같은 것 같은 것 같은 것 같은 것			1.1	ster 🖓 🚛 🐅 🛶 🖕 en statue en de statu
[백년] 김 교육 영향] [				1	0 0 1 * 1 AIDS
2.2. 2.2. 2.2. 2				<b> </b>	I O O O I VOR/DNB
	그는 대한 것 같은 것			. I	1 0 0 0 0 1 AIR DATA
				1	0 0 0 0   INERTIAL
a (1) 1	d	A	Α.	D 1	I F F O O I AUTOLAND
이 같은 사람이 있는 것을 가지 않는 것이 있는 것을 수 있다. 같은 사람이 있는 것은 것은 것이 같은 것이 같이 있는 것이 같이					1 0 0 0 0 1 ACTIVE FLUTTER CONTROL
				<b> </b>	100001 ENGINE CONTROL
		승규는 소리에 들어		( 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.	1 0 0 0 0 ATTITUDE CONTROL
		말하다 영국 가 같다.		al de la caste	L C C L J WEATHER
3(1)	đ	<b>λ</b>	λ.	B B	Ø . (HULL ABBAY)
				이 같은 것을 하는 것을 수 없다.	방법 이 가슴을 가지 않는 것 같은 것 같은 것 같은 것 같은 것 같이 있는 것 같이 있었다.
방법은 친구가 한 것이 !			양동 문화가 다니?		ORIGINAT -
방송 방송 관계 전 문화					OF DOOL PAGE TO
					LOOR OILAT
슬날 전문 한 것은 것을 가 있다. 1993년 - 1993년 - 1993년 1993년 - 1993년 - 1993년 1993년 - 1993년					
일을 알 수 있는 것이 없다.					전성은 문제를 많이 해외로 있는 것 같은 것은 것을 가지 않는 것 같은 것이 많이 있는 것이다.
영향 등 관계 등 관계				영국 김 승규님	
Alvan 1. Ohrea	1 - Takaaff //		Namos are defi	nod in	Por each row the regultant
Column 1: Pad SC	$1 - 1 \alpha Red LL/C$	rathe y	Tablo 2	1194 ±11	laval 1 tradactory got is
aluat la Diaco	L = Cruise D		1999.67.67.76 E.P		the intersection of the set
SULUMA DO CHASE	J - CLULAC L	4		승규는 가슴을 걸려 다 나는 것이 같이 하는 것이 같이 않는 것이 같이 하는 것이 같이 않는 것이 않는 것이 않는 것이 않는 것이 같이 않는 것이 않는 않는 것이 않는	anad in Column 7
ALIMAN III DAAROO					

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Table 3 Page 5 of 22

COMPLISHMENT	1	EVEL 1 PRCCU	CT TERMS		RESULTING
	ECONOMIES 1	OPERATICNS 1	PROPILE	SAFETY	
					0     0     1     *     AIDS       0     0     0     VOR/DHE       0     0     0     AIR DATA       0     0     0     AIR DATA
a (1)	a	<b>A</b>	B /		$\begin{array}{cccc} & \bullet & $
<b>1</b> (1)	i a		B	B	Ø (NULL ABRAY)
a (1) a (1)	d d	А	8 8	C D	Ø (NULL ARHAY) Ø (NULL ARRAY)
a (1) a (1)	i à		Ď	Ë	Ø (NULL AUBAY)
a (1)	l l l a	<b>a</b>	c		0     0     1     *     AIDS       0     0     0     VOR/DNE       0     0     0     AIR       0     0     0     *       1     0     0     *       1     *     *     INERTIAL       1     #     *     *
a (1) a (1) a (1)	d d d d	A	C C C	B C D	1       0       0       0       ACTIVE FLUTTER CONTROL         1       0       0       0       ENGINE CONTROL         1       0       0       0       Image: Artitude control         1       0       0       0       Image: Artitude control         1       0       0       0       Image: Artitude control         1       0       1       Artitude control         1       1       1       Artitude control </td
= (1) a (1)	l d l l l l l e		C		Ø     (HULL ARRAY)       Ø     (HULL ARRAY)       Ø     0 0 1       Ø     AIDS       Ø     VOR/DNE       Ø     Ø       Ø     O       Ø     VOR/DNE       Ø     Ø       Ø     INERTIAL       Ø     Ø       Ø     AUTOLAND
					1 0 0 0 0 1 ACTIVE PLUTTER CONTROL 4 1 0 0 0 0 1 ENGINE CONTROL 1 0 0 0 0 1 ATTITUDE CONTROL 4 # 0 # J WEATHER
a (1) a (1)	e e	$\lambda$	λ. Α	Br	Ø (NULL ABRAT) Ø (NULL ARRAY)
				1	
Lunn 1: Phas Lunn 2: Phas Lunn 3: Phas Lunn 4: Phas	1 = 1 = Takeoff/ = 2 = Cruise B = 3 = Cruise C = 4 = Landing	Cruise A   Na   Ta	mes are defin ble 2.	ed in	For each row, the resultant level 1 trajectory set is the intersection of the sets named in Column 2.

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CJN2LISHMENT	1	LEVEL 1 PEC	DUCT TERMS	بید ده میشین <u>ماند .</u>	RESULTING		
	ECONONICS	OPERATICUS	1 PROFILE	ISAPETY			
4 ( Ŋ	e			D	I       0       0       1       AIDS         I       0       0       0       VOR/DHE         I       0       0       0       AIR DATA         I       0       0       0       AIR DATA         I       0       0       0       INERTIAL         I       \$\$\vee\$       0       INTICLAND         I       0       0       0         I       0       0       INTICLAND         I       0       0       0         I       0       0       INTICLAND         I       0		
a (1) a (1)	e		B		0       0       1       AIDS         0       0       0       VOR/DHE         0       0       0       AIR DATA         0       0       1       INERTIAL         0       0       1       INERTIAL         0       0       0       ACTIVE PLUTTER CONTROL         0       0       0       ENGINE CONTROL		
i (1) a (1) a (1) i (1) i (1)	e e e	X A A X	B B B B B	B C D E	I       0       0       I       ATTITUDE CONTROL         I       L       E       0       E       I       WEATHER         I		
a (1)	e	λ.	C		0 0 0 1   AIDS           0 0 0 0   VOR/DHE           0 0 0 0   AIR DATA           0 0 0 0 *   INBRTIAL           \$\nothermid{\number} t *   AUTOLAND           0 0 0 0   ACTIVE FLUTTER CONTROL		
a (1) a (1) a (1) a (1)	e e e	A A A A	C C C C C	B C D Z	Image: Construction of the co		
Lunn 1: Phase Lunn 2: Phase Lunn 3: Phase Lunn 4: Phase	c 1 = Fakcoff/ c 2 = Cruise D d 3 = Cruise C d 4 = Landing	Cruise A	Names are defi Table 2.	ined in	For each row, the resultant level 1 trajectory set is the intersection of the sets named in Column 2.		

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Table 3 Page 7 of 22

COAPLISHMENT LEVEL		EVEL 1 PRCDI	ICT TERMS	· · ·	I LEVEL I TRAJECTORY SETS
	ECONOMICS 1	OPERATIONS 1	PROFILE 1	SAFETY	
a (2)		<b>b</b>			* * * *       AIDS         1 * * *       VOR/DHE         * * *       AIE DATA         0 0 0 *       INERTIAL         \$ \$ 0 *       AUTOLAND         0 0 0 0       ACTIVE FLUTTER CONTROL         0 0 0 0       ENGINE CONTROL         0 0 0 0       ATTITUDE CONTROL
1 (2) 1 (2)				B C	(RULL ARRAY)
a (2) a (2)		<b>b</b>		D	+ + + +       + AIDS         1 + + +       VOR/DHE         + + +       AIR DATA         0 0 0 0       INERTIAL         + # +       AIR DATA         0 0 0 0       INERTIAL         # # 0 0       AUTOLAND         0 0 0 0       ACTIVE FLUTTER CONTROL         0 0 0 0       ENGINE CONTROL         0 0 0 0       ATTITUDE CONTROL         - # # # #       WEATHER         (NULL ARRAY)
a (2)		<b>₽</b>	B	*	<ul> <li></li></ul>
a (2) a (2) a (2) a (2) a (2)		b b b b b	B B B B D	B C D B	I     0     0     0     I     ATTITUDE CONTROL       I     2     0     2     WEATHER       V     (NULL ABRAY)       V     (NULL ARRAY)
• (2)		<b>b</b>	<b>c</b>		+ * * *         AIDS         1 * * *         VOR/DME         + * * *         AIR DATA         0 0 0 *         INERTIAL         # # * *         AUTOLAND         0 0 0 0         ACTIVE FLUTTER CONTROL         0 0 0 0         ACTIVE FLUTTER CONTROL         0 0 0 0         ACTIVE CONTROL         0 0 0 0         ATTITUDE CONTROL
Lunn 1: Phas Lunn 2: Phas Lunn 3: Phas	I Se I = Takeoff/ Se 2 = Cruise B Se 3 = Cruise C	Cruise A   Na   Iz	nues are defi able 2.	ned in	Por each row, the resultant Por each row, the resultant level 1 trajectory set is the intersection of the sets

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#### LEVEL 1 BASED CAPABILITY FUNCTION

AJCONPLISIMENT	l Li	EVEL 1 PRCDU	CT TERMS	PESULTING TEALECTORY SEAS	
	ECONOMIES	OPERATIONS	PROFILE	SAFETY	LEVEL I TRAJECTORI SETS
a (2)	*	b	c	B	(NULL ARBAY)
a (2)	•	b	C	C	(NULL ARRAY)
a (2)	•	b	c j	D	(NULL ARRAY)
a (2)		b	с. ,	B	(NULL ARRAY)
					* * * * AIDS
요즘 것을 물건을 다 같아.					I I O I + + I VOR/DNE
					I I * * * * I AIR DATA
2004년 - 1412년 <b>(</b> )		영상 전 전 같이 없다.			I I O O O * I INBRTIAL
a (2)		C	λ.	A	I I E E O ¥ I AUTOLAND
	이 가는 관련을 얻는	말 같은 것 같은 것 같			I O O O O I ACTIVE PLUTTER CONTROL
	승규가 가지 않는 것	김 사람은 감독을 가지?			1 0 0 0 0 1 ENGLAR CONTROL
		김 영화 영화 영화 영화			1 1 0 0 0 0 ATTIIUDE CONTROL
					I COLE WEALINGA
a (2)		a 🖕 🖕 🖓 🖓 🖓		<b>,</b>	
1(4)		C			
					* * * * AIDS
			실패한 관감 - 영어로		I O I * * I VOR/ONE
					1 1 * * * *   AIR DATA
		이 같은 것이 같은 것이 같이 있다. 같은 것은 것이 같은 것이 같은 것이 같이 있다.			0 0 0 0   INERTIAL
a ((2)	li de la companya de	C	λ.	D	I I F F O O I AUTOLAND
집은 가슴 가슴 가슴 가					I I O O O O ACTIVE PLUTTER CONTROL
집안 다 가 가 같이 다	병일 관련 감독하는 것				I O O O O I ENGINE CONTROL
					I O O O O I ATTITUDE CONTROL
	에 물건을 받으려가 가지 않는다. 1993년 - 1993년 -				I CEETEJ WEATHER
a (2)		C		5	ACT VERY A
					+ + + + i AIDS
					0 1 0 * 1 VOR/DNE
					I * * O * I AIR DATA
					0 0 1 *   INERTIAL
a (2)		C	В	X ·	I I E E + + I AUTOLAND
집을 위한 바람이 없는 것	비행을 위해 가지 않는 것				I I O O O O ACTIVE PLUTTER CONTROL
					0000 ENGINE CONTROL
					I O O O O J ATTITUDE CONTROL
			<b>1</b>		I, FFUFJ HEATHER
a (2)		ç	U D	B /*	I P INDE ABRAI
	동안 물로 관련하는 것이	C C	2 1	Ň	TOPE ARVEL
a (2) > (2)			n	p	A CHILL ADD ADD ADD ADD ADD ADD ADD ADD ADD A
4 [4]			말 그 책임 그 것.		
	[일종 김종 아이지]				
			문 그는 말 것을 못 할 수 있다.		[] : 김 가지는 말을 물질했는 말을 가 수 있지? (P)
					사망가 전망가 있는 것이라는 것이라는 것을 했다. 같은 것은 것은 것은 것은 것은 것이 있는 것을 했다.
uan 1: Phase	1 = takes fi/C	ruise A   Na	ses are defin	ned in	Por each row, the resultant
Luwn 2: Phase	e 2 = Cruise D	l' Ia	ble 2.		level 1 trajectory set is
Charles and the second section in a second	A = Cruiso C	e de la companya de l			the interception of the cate

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#### Table 3 Page 9 of 22

ACCUAPLISAALAI		EL I PO	CLUCI ILAND		I TRUPI I TRIJETNOV CRTC
	ECONOMICS 1	PERATIONS	1 PROFILE 1	SAFETY	
					0 1 + +   VOR/DHE
					I + + + I AIR DATA
	변화 가 같은 것이다.		$\mathbf{I}$		I I O O O + I INERTIAL
a (2)		C	C		I F F I * I AUTOLAND
	말 같은 것 같은 것 같은 것		$(\mathbf{F}_{i}) = \mathbf{F}_{i}$		I I O O O O I ACTIVE FLUTTER COSTROL
					I I U U U I ENGINE CONTROL
					A ANTI TODAY
± (2)		C.	, c	ř	(NULL ARRAY)
J (2)	성학을 위한 것이 많이 같아.	C A	Ž	n	ANDLARRAY ORIGINAL PAGE
· · · · · · · · · · · · · · · · · · ·	그는 말을 하는 물고 문	ž	č	2000 <b>2</b> 000 - 2000	G (NULL ARRAY) OF POOR OTALL
3141	일 같은 것이 같은 것이다.			•	
					I A
방법 사람은 방법을 가려지 않는 것을 가지 않는 것을 것 같은 것은 사람은 사람들이 있는 것을 통하는 것을					1 0 0 1 + 1 VOR/DNE
					I TAR DATA DATA DE COMPTE SE
		한 것을 것 않는			I I O O O + I INERTIAL
€ (2)		đ	<b>.</b>	<b>.</b>	I I I I O I I AUTOLAND
동생님의 소설을 비용할 수 없다.	이 같은 것은 것을 많을 수 없다.				I I O O O O I ACTIVE FLUTTER CONTROL
					I O O O O I ENGINE CONTROL
	철말 가슴을 가 만들었.				I U U U U I ATTITUDE CONTROL
					T A AUNTY, ADDRYN
u (4) u (2)		. u 1		÷ č	a (NULL ARRAY)
4 (4)			• • • • • • • • • • • • • • • • • • •		
			이 지수는 물건을		I * * * * I AIDS
			en zere det		1 1 0 0 1 + 1 VOR/DHE
					I * * * * I AIR DATA-
					1 0 0 0 0   INERTIAL
a (2)		đ	λ	D	I I F F O O I AUTOLAND
	비야 지수는 것 같다.				1 1 0 0 0 0 1 ACTIVE FLUTTER CONTROL
					I O O O O I ENGINE CONTROL
	내 먹는 말 같은 것이 같은				I O O O I ATTITUDE CONTROL
	방송 동안 문제 문제 문제.				VEATHER
a (2)		U 3	A .	<b>4</b>	AUTTY ADDAY
4(4)		u A	D R	R	A CALL ADDAY
a (2)	n - Selan - Constant - Selan Na Santa - Selan	4	B	č	I INULL ARRAY
a (2) a (2)		7	B	n n n	I (NULL ARRAY)
a (2)		a	B	E	I (RULL ARRAY)
			이는 것 같은 옷이 없다.		
			한 문서 한 모습니다.		
생활 것은 가슴 가슴을 가지	말 같은 것을 가지?				비행 승규는 승규는 것을 많은 것이라. 그는 것이 같이 많이 있는 것이 없는 것이 없 않는 것이 없는 것이 않이
	[월명] 영화 등의 성장				4. 비행 방법은 영양 비행 위험에 가지 않는 것 같은 것이 없는 것이 없는 것이다.
	[월드] 것 26 대한 16				
		문제 다니 나라			
، خواجه مراجع که بول که بو که دو مراجع کا بو خو					
Columa 1: Phase	e 1 = Takeo ff/Cr	uise A	Names are defi	ned in	For each row, the resultant
Column 2: Phase	$e_2 = Cruise_B$		IADIG 2.		1 Level 1. Trajectory set 15
Joluan 3: Phas	$c_3 = cruise C$	고 한 분들을 모두 나라요.			I the future section of the SOLS

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COMPLISHMENT	L	IVEL 1 FRCDI	RESULTING		
	ECONOMICS	OPERATIONS I	PROPILE	SAFETY	
					1 r -
	المربعة المربعة المسترين في المربع وال	n an			AIDS
	[12] 김 영화 전 영화				I O O I + I YOR/DME
					I I V V V I ALU DATA
			1 - <u>1</u>		O O O T INERTIAL
a (2)		٩	<b>-</b>	•	I IFFI I T AUTULAND
					I I O O O O I ACLIVE FEDILES CONTROL
5 CA		1997 <b>,</b> 1997 - 1997		<b>R</b>	I OF INHTI APRAY)
3 (2)		a de la companya de l	ž	č	A ANULL ARRAY
4 (4)		a da anti-	2 - See 2	ñ	A SHILL ARRAY
3 (4)			č	, i i i i i i i i i i i i i i i i i i i	I A INTEL ARRAY
α ( <b>α</b> )					A CHIEF ARRAY
	말 같은 것을 많이 봐.				
					I I + + + I ATDS
					I I D O O 1 I VORZDME
					I I * * * *   AIR DATA
		말 같은 것을 물고 있었다.			I I O O O + I INERTIAL
a (2)	그는 이야 수요 같이 ?	6	8	۸	I I F F O * I AUTOLAND
					I O O O O I ACTIVE PLUTTER CONTRO
		한 것을 수 없는 것이다.		실험 소리 힘들었다.	1 1 0 0 0 0 1 ENGINE CONTROL
					I O O O O I ATTITUDE CONTROL
	일을 받은 것이 있는 것이다. 같은 것이 같은 것이 같은 것이 같이 있는 것이 있는 것이 있는 것이 있는 것이 있는 것이 있는 것이 있 같은 것이 같은 것이 같은 것이 같은 것이 같은 것이 같이 있는 것이 없는 것이 있	이 같이 걸려 들었다.			L F F O F J BEATHER
a (2)	•	е	λ.	B	(NULL ARRAY)
a (2)		e	8	C	I Ø (NULL ABRAY)
	방법 문화 감독 문화				
		승규는 것 같은 것이 있는 것			I I P P P F I ALK DAIA
					I I U U U U I INBELIAL
a (2)		8	<b>A</b>	9	
	김 승규는 감소가 가슴다.	영화에 가장 가장 가장			I I O O O O I ACTIVE FEUTIER CONTRE
	사람은 방법을 걸려졌다.	한 영향 같은 것을 통하는			
	승규는 것이 그 같은 것이다.				I L C C I C L URETHER
/ 21				<b>y</b> (*	I G (NULT ARPAY)
- <b>* * * /</b>	지수 않는 것을 가슴을 챙겨 봐. 동일에 가슴을 물려 다 가슴.				
	병학 중 문화가 다				I I O O I I VORZDER
					t t * * 0 * t ATR DATA
	영영 관람이 가지 않는 것이 없다.				I I O O I * I INERTIAL
a (2)	성상 등 상품을 위한 것이다. 이번 등 일종 <b>등</b> 가지 않는 것이다.	e	B	<b>x</b>	I S S * * I AUTOLAND
	2012년 1월 2012년		이 옷을 깨끗 감소 물		I I O O O I ACTIVE FLUTTER CONTRO
		이는 이는 것은 것은 것이 있는 것이다. 이는 것이 같은 것이 같은 것이 같이 있는 것이다.			I I O O O I ENGINE CONTROL
사가 바람은 것을 알려요. 1993년 2월 1993년 1993년 1993년 1993년 199	민준이는 것을 가지?	말한 같은 요마?			I I O O O I ATTITUDE CONTROL
	17 : 12 : 13 : 13 : 13 : 13 : 13 : 13 : 13				I LE COE J VEATHER
1 uno 1. Diama		ruico 1 1 Va	mes are deft	ned in	1 Par each row, the resultant
lumn 2: Dhace	-2 = Cruice R	сода с а ј во / ј Та	hle 2.	42	I level 1 trajectory set is
tumn l. Dhama	2 = Cruico C	10	₩ <b>4</b> ₩ <b>6</b>		the intersection of the cote
LUGI J. CIGSU		물 수집 방법 이 되는 데 이 이 있는 것			LUN THECT DECEANIL OF FIRE SOLD

것 같은 한 것 주말을 만들었는 것 좋아? 가 봐야? 가 봐야?

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SCOAPLISHKENT		LEVEL 1 PRCEU	CT TERMS		TPUPT	RESULTING
<b>1</b> 6751	ECONOMIES	OPERATIONS 1	PROFILE	SAFETY		
a (2)	*	e	8	B	1 9	(NULL ARRAY)
a (2) 1	•	6	8	<b>C</b>	l 🦉	(NULL ARRAY)
a (2) - 1		6	B	D	l Ø	(NULL ARRAY)
a (2)	alan <b>≭</b> akara Basi Sita	ė	B	8	9	(NULL ARRAI)
					i i * * * * i	AIDS
	김 글로 한 것 같다.				1 0 0 0 1 1	VOR/DME
						AIR DATA
					0 0 0 •	INGUTIAL
a (2)		<b>e</b>		•		ACTIVE PLUTTER CONTRO
	물론화 나는 것이다.				00001	ENGINE CONTROL
	이 말할 것 같은 것 같은 것을 했다.	승규는 것을 가지 않는다.			100001	ATTITUDE CONTROL
	전기를 만들는 것				LEEDES	VEATHER
a (2)		e	C	B	1	(NULL ABRAY)
a (2)	•	6	C	C	l 🦉	(NULL ABRAY)
a (2) 🔰 👔	이 이상 등을 🔹 특별하여 이 가격했다.	e	C	D	l 🦻	(NULL ARBAY)
1(2)	승규는 옷 집에 가지?	е	C	Ľ	Į.	(NULL ARRAI)
		그는 말 알 가 봐. 가 물			l r	
		지금 물건을 가지는 것을 못했다.				VOB JONP
					1 1 + 1 + + 1	ATR DATA
			말 이 것 같은 것 같은		1 1 0 0 0 + 1	INERTIAL
4 (2) i	•	£	8	λ.	1 2 2 0 + 1	AUTOLAND
	할 것은 말 같은 날				100001	ACTIVE FLUTTER CONTRO
		비원을 가지 않는다.			1 0 0 0 0 1	ENGINE CONTROL
•					1 1 0 0 0 0	ATTITUDE CONTROL
					LEEOEJ	WEATHER
a (2)			<b>.</b>	C	p p	(NULL ARRAI) (NULL ARRAY)
	28년 1월 1일에 1월 1일에				1 7	
						ATP DATA
					10000	TNERTTAL
a (2)	이 집에 🔹 문화된	f	λ.	D		AUTOLAND
		이 아이 집안 한 것이 없다.			1 0 0 0 0 1	ACTIVE FLUTTER CONTRO
		한 날 물건가 있는 것이 없었다.	방법 전 전쟁 전 그는 것을 받는		1 0 0 0 0 1	ENGINE CONTROL
이 같은 것이 같아.	. 김 영화가 한 것을 가 있었다. 1943년 - 이 영화가 이 것을 하는 것을 수 있다.				1 0 0 0 0 1	ATTITUDE CONTROL
						WEATHER
a (2)	영상 강 한 동안 등 것 같이 같이 같이 같이 같이 같이 같이 같이 같이 같이 않는다.		<b>A</b>	Z	1. Sec. 7. 18 -	(NULL ARRAT)
				이는 바람이다.	* * *	
Olumn 1: Phase	1 = Takeo ff/	Cruise A   Na	nes are defin	ed in	For each ro	w, the resultant
Colugu 2: Phase	2 = Cruise E	)   Ia	ole 2.		level 1 tra	jectory set is
Colugn 3: Phase	3 = Cruise C				the interso	ction of the sets
Column 4: Phase	4 = Landing	$\sim 1$			named in Co	Lunn 2.

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ACCOMPLISHMENT LEVEL		EVEL 1 PROD	UCT TERMS	RESULTING LEVEL 1 TRAJECTORY SETS		
	ECONOMICS	OPERATICNS 1	PROPILE 1	SAPETY		
					AIDS	
양 전 문화 영화 문화					1 1 0 0 0 0 VOR/DHE	
승규는 감독을 위한 것이 없는 것이 없다.		물 위험 관계 관계 관계			I I I I O I I AIR DATA	
			7			
± (2)		<b>L</b>	D		I I O O O O I ICAIAS SINAASD COMAD	1
	19년(1), 10년 - 10년(1) 11년 - 11년(1), 10년(1), 1				I I O O O O I RECEIVE FLOTIER CONTR	
					1 1 0 0 0 0 1 ATTITUDE CONTROL	
					I L S S O S J. YBATHER	
<b>1</b> (2)	방송한 3 비밀었다.	E	B	В	(NULL ARRAY)	.•
a (2) 🔰 🔰	이 병원 이 비슷한 것은	<b>f</b>	B	C	(NULL ARRAY)	
<b>4 (</b> 2)		f	B	D	(NULL ARRAY)	
u (2) 🕴 🕴	, 영화, 100 March	e e e e e e e e e e e e e e e e e e e	В	E	(BULL ARRAY)	
양 것은 영상을 가지 않는						
					C L O O O O T ALVA I ALDA E EN CONTRA	
		이는 별로 가격하는 것을 못 같이 가지 않는 것이 같아.			I O O O + I INERTIAL	
a (2)		ſ	C	1	I # # 1 * I AUTOLAND	
	이 같은 것은 것을 같이 없다.				1 0 0 0 0 1 ACTIVE PLUTTER CONTR	OL
	방송한 방송 가슴 가슴				1 0 0 0 0   ENGINE CONTROL	
					I I O O O I ATTITUDE CONTROL	
					I LEEUEJ WEATHER	
a (s)			<u> </u>	8	NULL ANKAI	
4 ( <i>C</i> ) 3 (2)	이에 위에 있는 것이 가지 않는 것이 있다. 같은 것이 있는 것이 있는 것이 있는 것이 있는 것이 같이 있는 것이 같이 있는 것이 있는 것이 같이 있는 것이 같이 있는 것이 있는 한		ž	D	W INULL ARRAY	
a (2)		Ē	č	E	Ø (NULL ABRAY)	
1			문화 관람은 것이 있다.			
이는 가장 등 것 같이 있는 것 같이 있다. 같은 것 같은 것 같은 것 같은 것 같이 있는 것 같이 있 같은 것 같은 것 같은 것 같은 것 같은 것 같이 있는 것	1월 28일 - 2012년 - 2013년	철물 것은 동생을 받는				• •
	철왕이 가슴을 다.		그는 아이는 것을 물었다.		$\begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\$	
a 4 2 1 1		σ '		1	$I \leq I \leq 0 + 1$ AUTOLAND	
				•	0 0 0 0 1 ACTIVE PLUTTER CONTR	0L
			같은 것은 것이 같아.		I O O O I ENGINE CONTROL	27
					0 0 0 0   ATTITUDE CONTROL	
발생한 소한 날 왜 하		사람은 동안에 있는 것이 가격했다. 1997년 - 1997년 - 1997년 1997년 - 1997년 -			LEEOE WEATHER	
a (2)		9	A .	B	Ø (NULL ARRAY)	
a (2)		g	A .	C	Ø (NULL ARRAY)	1
2019년 1월 28일 - 1일 - 1일 2일 - 1일 - 1일 - 1일 - 1일 - 1일 - 1일 2일 - 1일 -						
		영상 물로 상태되었는	전철 소리는 것으로 주셨다.		이나 이 가지 않는 것이 가지 않는 것이 가지 않는 것이다. 이 아이에 있는 것이 같은 것이 가지 않는 것이 같은 것이 없는 것이다.	
	가 가지 않는 것 같이 가락했어. 가지 가지 않는 것이 가지 않는 것이 같이 있다.					
	2011년 1월 1943년 1947년 1월 1943년 1월 19	경상은 성장님께서				
					그는 것 같은 것을 가 물을 가지 않는 것을 물었다.	
				المدين محمد ومستواحت		
oLuga 1: Phase	1 = Takeoff/	Cruise A   Na	mes are defi	ned in	For each row, the resultant	
olumn 2: Phase	2 = Cruise B	,i Ta	bie 2.		level 1 trajectory set is	
orumn J: Phase	3 = Cruise C				the intersection of the sets	
JIUIN 4: PRASE	4 - Lanuing	가 물질 것 이 것 것 같아. 아이는 것			Hamed TH COLUMN T.	

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DAPLISHMENT		LEVEL 1 PROCU	CT TERMS		RESULTING	
	FCONONICS	OPERATICNS 1	PROFILE 1	SAFETY		
J.(2)		9	· /		* * * *       AIDS         0 0 0 0       • VOR/DHE         0 1 * *       AIB DATA         0 0 0 0       INERTIAL         \$	
a (2)		g		8	BE IE - WEATHER B (NULL ARRAY)	
a (2)		g	8		* * * *       AIDS         0 0 0 0       VOR/DHE         0 1 0 *       AIR DATA         0 0 1 *       INERTIAL         ¢ ¢ * *       AUTOLAND         0 0 0 0       ACTIVE PLUTTER CONTROL         0 0 0 0       BNGINB CONTROL         0 0 0 0       ATTITUDE CONTROL	
a (2)		g	B	B	B (NULL ARRAY)	i de la composición de la comp
a (2) a (2)		d d	B B	C D	Ø (NULL AHRAT) Ø (NULL ARBAY)	- 1
a.(2)		9	¢		• • • •       AIDS         0 0 0 0       VOR/DRE         0 1 • •       AIR DATA         0 0 0 •       INBRTIAL         \$	POOR QUAT
a (2) a (2)		9 9	C C	B C	Ø (HULL ARRAY) Ø (HULL ARRAY)	
a (2) a (2)		ġ g	C C	D B	Ø (NULL-ARRAY) Ø (NULL ARRAY)	
unn 1: Phas unn 2: Phas unn 3: Phas	I e 1 = Takeoff/ e 2 = Cruise B e 3 = Cruise C e 4 = Landi po	Cruise A   Ba   Fa   Fa	mes are defin ble 2.	ed in	For each row, the resultant level 1 trajectory set is the intersection of the sets named in column 2	

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ACCUMPLISHMENT ( LEVEL		LEVEL 1 PFOI	DUCT TERMS		RESULTING Level 1 trajectory sets	
	ECONOMICS	UPERATICNS	PROFILE	SAPETY		
a (2) a (2) a (2) a (2)		h h h	A. A. A.	B C	* * * *         AIDS         0 0 0 0         VOR/DME         0 0 1 *         AIR DATA         0 0 0 *         INERTIAL         \$\notheta 0 *         AUTOLAND         0 0 0 0         ACTIVE PLUTTER CONTROL         0 0 0 0         ATTITUDE CONTROL         0 0 0 0         ATTITUDE CONTROL         \$\notheta 0 \$\notheta 0\$       WEATHER         \$\notheta 0\$       (NULL ABRAY)	
ال ع (2)		<b>h</b> .		D	* * * *   AIDS         0 0 0 0   VOR/DME         0 0 1 *   AIR DATA         0 0 0 0   INERTIAL         \$ \$ 0 0   AUTOLAND         0 0 0 0   ACTIVE FLUTTER CONTROL	
a (2) a (2) a (2) a (2) a (2) a (2)		h h h h h	A D B B - B - B	E A B C D	1       0       0       0       1       ENGINE CONTROL         1       0       0       0       1       ATTITUDE CONTROL         1       1       2       WEATHER       Ø       (NULL ARRAY)         9       (NULL ARRAY)       Ø       (NULL ARRAY)	
a (2) a (2)		h	C C		Ø (NULL ARRAY)	
1 (2) 4 (2) 3 (2) 4 (2) 4 (2)		h h h h b	C C C C C	B C D E	I       0       0       0       I       ENGINE CONTROL         I       0       0       0       I       ATTITUDE CONTROL         I       0       I       I       I       I       I         I       0       I       I       I       I       I       I         I       0       I	
Luga 1: Phas	e 1 = Takeoff,	Cruise A L	ames are defi	ned in	Por each row, the resultant	

to the art allow which is the set of the set of the set of the set of the set

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SCONPLISHMENT	l LE	VEL 1 PRODU	PESULTING		
	ECONOMICS	OPERATIONS 1	PROFILE I	SAPETY	
a (2)					I       + + +   : AIDS         I       0       0       I         I       0       0       1       I         I       0       0       1       I         I       0       0       1       I         I       0       0       +       I         I       0       0       +       I         I       # # 0       +       I       AUTOLAND         I       0       0       0       ACTIVE PLUTTER CONTROL         I       0       0       0       ENGINE CONTROL
a (2) a (2)				B C	I C C C C J WEATHRE C C C C J WEATHRE I G (NULL ARRAY) I G (NULL ABRAY) I T J S
a (2)				D	I       + + + I       AIDS         I       I       0       0       I         VOR/DHE       I       OR/DHE       I         I       I       0       0       I         I       I       0       0       I         I       I       0       0       I         I       I       0       0       I         I       I       I       I       I         I       I       I       I       I
a (2)					I     0     0     0     I
a (2)			3		* * * *       AIDS         1 0 0 0 0       VOR/DME         0 0 1 1       AIE DATA         0 0 1 *       INERTIAL         2 2 * *       AUTOLAND         1 0 0 0 0       ACTIVE FLUTTER CONTROL         0 0 0 0       ATTITUDE CONTROL         0 0 0 0       ATTITUDE CONTROL
a (2) a (2) a (2) a (2) a (2)			B B B B	B C D E	Image: Second
a (2)		<b>.</b>	<b>e</b>		* * * *       AIDS         0 0 0 0       VOR/DME         0 0 0 1       AIR DATA         0 0 0 *       INERTIAL         \$\$\employ\$ \$\employ\$ 1 \$\employ\$ INERTIAL         \$\$\employ\$ \$\employ\$ 1 \$\employ\$ INERTIAL         \$\$\employ\$ \$\employ\$ 0 \$\employ\$ \$\employ\$ INERTIAL         \$\$\employ\$ \$\employ\$ 0 \$\employ\$ \$\employ\$ INERTIAL         \$\$\employ\$ \$\employ\$ 0 \$\employ\$ \$\employ\$ INERTIAL         \$\$\$\employ\$ \$\employ\$ 0 \$\employ\$ \$\employ\$ INERTIAL         \$
)Luga 1: Phase )Luga 2: Phase )Luga 3: Phase )Luga 4: Phase	= 1 = Takeoff/C = 2 = Cruise B = 2 = Cruise C = 4 = Landing	ruise A   Na   Tai	mes are defi ble 2.	ned in	For each row, the resultant level 1 trajectory set is the intersection of the sets named in Column 2.

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CCOMPLISHMENT		LEVEL T PPCI	OCT TERHS	RESULTING	
LI, V Lit.	ECORORI : S	DEEPATIONS 1	PHOFILE	SAFERY	LEVEL I TRAJECTORY SETS
a (2) a (2) a (2) a (2) a (2) a (2)	*	i	C C C C	B C D E	Ø(NULL ARRAY)Ø(NULL ARRAY)Ø(NULL ARRAY)Ø(NULL ARRAY)
<b>a (3)</b>			đ	A	$* * * *$ AIDS $* * * *$ VOE/DME $* * 1 *$ AIR DATA $0 0 1 *$ INERTIAL $\not \not \not \not \not \not &                         $
4 (3)			đ	В	* * * *       AIDS         * * * *       VOR/DHE         * * 1 *       AIR DATA         0 0 1 *       INERTIAL         2 £ 1 *       AUTOLAND         0 0 0 0       ACTIVE FLUTTER CONTROL         0 0 0 0       ACTIVE FLUTTER CONTROL         0 0 0 0       ACTIVE CONTROL         0 0 0 0       ATTITUDE CONTROL         + £ 1 £       WEATHER
a (3)			â	C	* * * *       AIDS         * * * *       VOR/DNB         * * * *       VOR/DNB         * * * *       AIR DATA         0 0 1 *       IMERTIAL         ¢ ¢ 0 *       AUTOLAND         0 0 0 0       ACTIVE FLUTTER CONTROL         0 0 0 0       ENGINE CONTROL         0 0 0 0       ATTITUDE CONTROL
   (۲) ه   ۱	*		đ	D E	L # # 1 # J WEATHER [# (NULL ARBAY] # (NULL ABRAY]
a (3)		3			* * * *       NIDS         * * 1 *       VOR/DME         * * 0 *       AIR DATA         0 0 1 *       INEBTIAL         * 2 * *       AUTOLAND         0 0 0 1 ACTIVE FLUTTER CONTPOL         0 0 0 1 EUGINE CONTPOL         0 0 0 0 EUGINE CONTPOL
i Vivil II diss Land die Bhord Vivil 2: Dhair Vivil 2: Dhair		La grand di Strag Vela Gibin Gibin Maria Statu Maria Statu	alas at a support		Cold roop the resultant Cold roop the resultant Cold content Cold cold cold the sets Cold cold cold cold cold cold cold cold c

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ACCOMPLISH HENT LEVEL	LEVEL. 1 PRCEDO	TTERNS	RESULTING	
	ECONUMICS   OFERATIONS	PROFILE	SAPETY	
a (J)		/ • / •		* * * *         AIDS         * * 1 *         VOB/DHE         * * 0 *         AIR DATA         0 0 1 *         INERTIAL         # # 1 *         AUTOLAND         0 0 0 0         ACTIVE FLUTTZE CONTROL         0 0 0 0         ENGINE CONTROL         0 0 0 0         ATTITUDE CONTROL         0 0 0 0         ATTITUDE CONTROL
a.(3)			C	* * * * :       AIDS         * * 1 * :       VOR/DNE         * * 0 * :       AIR DATA         ! 0 0 1 * :       INERTIAL         ! \$\nothermid{s} 0 * :       AUTOLAND         ! 0 0 0 0 :       ACTIVE FLUTTER CONTROL         ! 0 0 0 0 :       ENGINE CONTROL         ! 0 0 0 0 :       ATTITUDE CONTROL
a (3) a (3) a (3) a (3) a (3) a (3) a (3)		e f f f f f	D E A B C D	Ø(NULL ARRAY)Ø(NULL ARRAY)Ø(NULL ARRAY)Ø(NULL ARRAY)Ø(NULL ARRAY)Ø(NULL ARRAY)Ø(NULL ARRAY)
a (3)				* * * *     AIDS       * * * *     VOR/DNB       * * * *     AIB DATA       1 * * *     INBRTIAL       \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$
a (3)				* * * *         AIDS         * * * +         VOR/DNE         * * * +         AIR DATA         0 1 * *         INERTIAL         * # * +         AUTOLAND         0 0 0 0         ACTIVE PLUTTER CONTROL         0 0_0 0         ENGINE CONTROL         0 0_0 0         ATTITUDE CONTROL         \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$
Luna 1: Phase Luna 2: Phase Luna 3: Phase Luna 4: Phase	1 = Takeoff/Cruise A   Nar 2 = Cruise B   Tab 3 = Cruise C   4 = Landing	es are define le 2.	ed in	For each row, the resultant level 1 trajectory set is the intersection of the sets named in Column 2.

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CJAPLISHMENT	1	EVEL 1 PRCEU	RESULTING		
LEYEL	ECONONICS	OPERATIONS 1	PROPILE	SAFETY ·	
à (3)			9	8	Image: State of the state
a (3)				C	* * * *       AIDS         * * * *       VOR/DNE         * * * *       AIR DATA         0 1 1 *       INERTIAL         1 £ £ 0 *       AUTOLAND         0 0 0 0       ACTIVE FLUTTER CONTROL         0 0 0 0       ENGINE CONTROL         0 0 0 0       ATTITUDE CONTROL         0 0 0 0       HATTITUDE CONTROL         0 0 0 0       HATTITUDE CONTROL
a (3) a (3) a (3) a (3)			9	D 2 4	* * * *       AIDS         * * * *       VOR/DHE         * * * *       AIR DATA         0 1 0 0       IMERTIAL         * * * *       AIR DATA         0 1 0 0       IMERTIAL         * * * *       AIR DATA         0 1 0 0       IMERTIAL         * # * 0 0       AUTOLAND         * 0 0 0       CONTROL         0 0 0 0       ENGINE CONTROL         0 0 0 0       ATTITUDE CONTROL         * # 1 # J       WEATHER         Ø       (NULL ARRAY)         Ø       (NULL ARBAY)
a(J)			h		* * * *       AIDS         * * * *       VOR/DNE         * * * *       AIR DATA         0 0 0 *       INERTIAL         # # *       AUTOLAND         0 0 0 0       ACTIVE FLUTTER CONTROL         0 0 0 0       ENGINE CONTROL         0 0 0 0       ATTITUDE CONTROL         0 0 0 0       WEATHER
a (3) a (3) a (3) a (3) a (3)			h h h	C D B A	Ø     (NULL ARRAY)
oluna 1; Phas oluna 2; Phas oluna 3; Phas oluna 4; Phas	I e 1 = Takeoff/ c 2 = Cruise B e 3 = Cruise C e 4 = Landing	Cruise A L. Na   Ta	mes are defi ble 2.	ued in	For each row, the resultant level 1 trajectory set is the intersection of the sets named in Column 2.

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COMPLISHMENT	LEVEL 1 PRCDUCT 1ERMS		RESULTING
LEVEL	ECONOMICS   OPERATIONS   PROFILE	SAPETY	LEVEL I TRAJECTORI SETS
z (3)		B	$\bullet$ <
a (3) a (3)		C	* * * *       AIDS         * * 0 *       VOR/DME         * * 0 *       AIR DATA         1 0 0 1 *       INERTIRL         1 \$\nothermodellimetermode
d (3)		E	(NULL ABRAY)
a (4)			* * * *     AIDS       * * * *     YOR/DME       * * *     AIR DATA       * * *     INEBTIAL       * * *     INEBTIAL       * * *     AUTOLAND       1     * * *       1 * * *     ACTIVE FLUTTER CONTROL       * * *     ENGINE CONTROL       * * *     ATTITUDE CONTROL       * * *     ATTITUDE CONTROL       * * *     HEATHER
a (4)		g	<pre>**** AIDS **** VOR/DME **** AIE DATA **** AIE DATA **** AIE DATA **** AUTOLAND 0*** AUTOLAND 0*** ACTIVE FLUTTEE CONTROL 1*** ENGINE CONTROL **** ATTITUDE CONTROL **** ATTITUDE CONTROL **** VEATHER</pre>
ilumu 1: Phas Ilugn 2: Phas Ilugn 3: Phas Ilugn 4: Phas	e 1 = Takeoff/Cruise A   Hames are define e 2 = Cruise B   Table 2. e 3 = Cruise C   e 4 = Landing   1	nci in	Por each for, the resultant level 1 trajectory set is the intersection of the sets named in Column 2.

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ALCONPLISHMENT	LEVEL 1 PRCCU	CT TERMS	
LEV EL	ECONOMIES   OPERATIONS	PROPILE I SAFETY	
a (4)			* * * *     AIDS       * * * *     VOR/DME       * * * *     AIR DATA       * * * *     INERTIAL       * * *     INERTIAL       * * *     AUTOLAND       0 * *     ACTIVE FLUTTER CONTROL       0 * *     ENGINE CONTROL       1 * *     ATTITUDE CONTROL       2 * ¢ J     WEATHER
a (4)			+ * * *       AIDS         + * * *       VOR/DME         + * * *       AIR DATA         + * * *       AIR DATA         + * * *       INERTIAL         + * * *       INERTIAL         + * * *       AUTOLAND         + * *       AUTOLAND         + * *       ENGINE CONTROL         + * *       ENGINE CONTROL         + * *       ATTITUDE CONTROL         + * *       WEATHER
- <b>- (4)</b>		•	****     AIDS       ****     VOR/DNE       ****     VOR/DNE       ***     AIR DATA       0***     INERTIAL       ***     AUTOLAND       0     **       ***     AUTOLAND       0     **       ***     ENGINE CONTROL       0     **       ***     ATTITUBE CONTROL       ***     ATTITUBE CONTROL       ***     ***
a (4)			<pre>     **** AIDS     VOR/DNE     *** AIR DATA     O **    INERTIAL     c **    AUTOLAND     O 0 **    AUTOLAND     O 0 **    ACTIVE PLUTTER CONTROL     O 0 **    ENGINE CONTROL     O 1 **    ATTITUDE CONTROL     c *</pre>
Column 1: Phas Column 2: Phas Column 3: Phas Column 4: Phas	e 1 = Takeoff/Cruise A   Na e 2 = Cruise B / 1 Ta e 3 = Cruise C   e 4 = Landing	mes are defined in ble 2.	For each row, the resultant level 1 trajectory set is the intersection of the sets named in Column 2.

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CLAMPLISHMENT	LEVEL 1 PRODUCT	E TERMS	RESULTING
LEVFL	ECONONICS   OPERATIONS	PROFILE I SAFETY	LEVEL I THAJELTURI SETS
a (4)			AIDS       VOR/DNE       AIR DATA       O * *       INERTIAL       C * *       AUTOLAND       O 1 *       ACTIVE PLUTTER CONTROL       O 0 *       ENGINE CONTROL       O 0 *       ATTITUDE CONTROL       V *       V *
<b>~ {4</b> )			* * * *     AIDS       * * * *     VOR/DME       * * * *     AIR DATA       0 * * *     INERTIAL       \$ \$ \$ * *     AUTOLAND       0 0 0 *     ACTIVE FLUTTER CONTROL       0 0 1 *     ENGINE CONTROL       0 0 * *     ATTITUDE CONTROL       \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$ \$
a (4)			AIDS       VOR/DME       AIR DATA       O * * *       INERTIAL       O * * *       INERTIAL       O 0 * *       AUTOLAND       O 0 0 *       ACTIVE FLUTTER CONTROL       O 0 0 *       ENGINE CONTROL       O 0 1 *       ATTITUDE CONTROL       PATHER
a (4)			* * * *       AIDS         * * * *       VOR/DME         * * * *       AIR DATA         0 * * *       IHEBTIAL         # * * *       AUTOLAND         0 0 0 1       ACTIVE PLUTTER CONTROL         0 0 0 *       ENGINE CONTROL         0 0 0 *       ATTITUDE CONTROL         0 0 0 *       ATTITUDE CONTROL         0 0 0 *       HEATHEE
oluma 1: Phase oluma 2: Phase oluma 3: Phase oluma 4: Phase	e 1 = Takeoff/Cruise A   Name e 2 = Cruise B   Tabl e 3 = Cruise C   r 4 = Landing /	s are defined in personal state of the state	For each row, the resultant level 1 trajectory set is the intersection of the sets named in Column 2.

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Table 3 Page 22 of 22

JAPLISHMENT	LEVEL , 1 PRODUCT TERMS	I RESULTING I LEVEL I TRIJECTORY SPTS
	ECUNOMIZS   OPERATIONS   PROFILE	SAPETY J
a (4)		P P P P P P P P P P P P P P
<b>4 (4</b> )		Image: State of the state
a (4)		* * * *     AIDS       * * * *     VOR/DHE       * * * *     AIR DATA       0 * 0 *     INERTIAL       * * * 0 1     AUTOLAND       0 * 0 0     ACTIVE FLUTTER CONTROL       0 0 0 0     ENGINE CONTROL       0 0 0 0     ATTITUDE CONTROL       * * 1 *     WEATHER
± (4)		* * * *       AIDS         * * * *       VOR/DNE         * * * *       AIR DATA         0 * 0 1       INERTIAL         5       # # * *         1 0 * 0 1       INERTIAL         5       # # * 0 0         1 0 0 0 0       - ACTIVE FLUTTER CONTROL         0 0 0 0       - ACTIVE FLUTTER CONTROL         0 0 0 0       - ACTIVE CONTROL         0 0 0 0       - ATTITUDE CONTROL         - # # 1 # J       WRATHER
.ura 1: Phase Lucn 2: Phase Lucn 3: Phase Lucn 4: Phase	e 1 = Takeoff/Cruise A   Names are defin c 2 = Cruise B .*  Table 2. e 3 = Cruise C . e 4 = Landing	ed in For each row, the resultant level 1 trajectory set is the intersection of the sets ramed in Column 2.

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ECONOMICS
 OPERATIONS
 PROFILE
 SAFETY

Using Table 2 to determine the sets  $(\xi_i \kappa_1)^{-1}(\xi_i (U_i))$  and designating the Cartesian components of these sets by their Table 2 names,

$(\xi_{i^{\kappa_{1}}})^{-1}(0$	) = A		p. 1, row 1)
$(\xi_{i}\kappa_{2})^{-1}(0$	) = A	· · · · · · · · · · · · · · · · · · ·	p. 2, row 1)
$(\xi_{i}\kappa_{3})^{-1}(0$	) = A U B U	C (p.	4, rows 1-3)
$(\xi_{i}\kappa_{5}')^{-1}(0$	) = A U B U	CUDUE	
	(p. 5	5, last row;	p. 6 rows 1-4).

Note that the set names used in Table 2 are "coordinate sensitive," e.g., the A's appearing above mean different trajectory sets for different coordinates. To illustrate the remaining computations, we resolve these ambiguities by adding subscripts, i.e.,

 $(\xi_{i}\kappa_{1})^{-1}(0) = A_{1}$   $(\xi_{i}\kappa_{2})^{-1}(0) = A_{2}$   $(\xi_{i}\kappa_{3})^{-1}(0) = A_{3} \cup B_{3} \cup C_{3}$   $(\xi_{i}\kappa_{4})^{-1}(0) = A_{4} \cup B_{4} \cup C_{4} \cup D_{4} \cup E_{4}.$ 

Accordingly, performing the intersection of equations (3.3.3) (where the symbols are omitted):

 $\gamma_1^{-1}(a_0) = A_1A_2A(A_3 \cup B_3 \cup C_3)(A_4 \cup B_4 \cup C_4 \cup D_5 \cup E_4)$ =  $A_1A_2A_3A_4 \cup A_1A_2A_3B_4 \cup \cdots \cup A_1A_2C_3E_4$ . Note that the above expression contains 15 "product terms" when fully written. Note also that, by developing the intersections in the above mannes — a subscripts are indeed redundant (i.e., the position of a letter is enough to resolve its meaning). Referring to Table 3, each row of the table beginning with entry a(0) corresponds to a product term in the above expression; the second column of the table displays the corresponding term (with subscripts removed); and the third column gives the resulting intersection of level 1 sets named by letters in the product term. (Since all letters name Cartesian sets and since the intersection of Cartesian sets is Cartesian, the resulting set is Cartesian).  $\gamma_1^{-1}(a_0)$ , then, is just the union of all the column 3 entries of rows beginning with a(0). Since all but four of these entries are null, the set of all level 1 trajectories corresponding to accomplishment level  $a_0$  is given by

This concludes the example.

 $\gamma_{1}^{-1}(a_{0}$ 

Table 3 is therefore a complete description of how behavior of the level 0 model relates to behavior of the level 1 model. In deriving the algorithm used to compute Table 3, emphasis was placed on finding gractical method that would work as opposed to

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one that would work most efficiently. The efficiency issue is one which must certainly be addressed at some future time, but for the present, we are primarily concerned with establishing the feasibility of the methodology.

The next section describes the computer model which comprises the bottom level of the model hierarchy.

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### 3.3.2 Computer Level Model

A computer model of the SIFT system is described in this The model employed is a non-homogeneous Markov process section. where such processes have been discussed in previous reports (see [2], Section 3.4.2 and [3], Section 3.4.3). The purpose of the computer model is to provide a description of the probabilistic nature of the SIFT system, which is able to change its configuration due to phase changes or to failures occurring during use. As compared with the Markov model for the SIFT system described in [8], the salient feature of the model is that the partitioning of the system is based on both the system's available resources as well ar the computational requirements of a given phase. Moreover, since the SIFT system reconfigures in accordance with the task allocation algorithm, we believe that the model should also be tailored to the specific task allocation algorithm selected. Accordingly, the Markov model described here has the advantages that (i) it is more compatible with the higher level models developed in Section 3.3.1 of this report, (ii) the level of detail of the model depends on the user's application.

In the following discussion, it is assumed, as in [8], that the SIFT computer is comprised of a number of processor-memory modules connected to the busses as shown in Figure 4. It is also assumed that the detection and location of processor and bus failures is carried out by the method described in Chapter IV of [8]. In order to relate the state behavior of the bottom model (level 2) to that of the aircraft functional task model (level 1) the phases of the level 1 model are further decomposed into eight phases at level 2, as shown in Table 4.





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	Level 2 Phases	Correspo	nding Level 1 Phases
Phase No.	Description ,	. Phase No.	Description
1	Take-off		
2	Climb	1	Take-off/Cruise A
3	Cruise I		
4	Cruise II	2	Cruise B
5	Cruise_III		
6	Decent	3	Ċruise_C
	Approach		
8	Landing	4	Landing

TABLE 4 Level 1 and Level 2 Phases

#### 3.3.2.1 Task Allocation

In order to derive the computer model for the SIFT system, it is necessary that the state space of the model be refined enough to distinguish different levels of degraded performance for the system. This condition can be satisfied when the states of the model are chosen to represent different processing capabilities of the system. For example, the state "5 processor and 4 busses" insures that all tasks required to support take-off phase can be accomplished by the system. On the other hand, the state "4 processors and 4 busses" accomodates a reduced workload wherein Inertial System computations are discarded. Since the task profiles are different for different phases, relations between different states and system processing abilities must be established for each phase.

System reconfiguration can occur in the SIFT computer due to phase change, pilot intervention, fault detection and location, etc. It is determined by the Local Executive and the Global Executive using a precomputed task allocation algorithm. Although the feasibility of such a task allocation algorithm has been demonstrated in [8], it is not completely specified. For the purpose of developing a computer model, we have applied the basic design principles described for the SIFT system to develop a workable task allocation algorithm. This allocation algorithm is then accounted for (see Section 3.3.2.2) in the derivation of the Markov process representation of the computer.

The basic parameters for determining a task allocation algorithm are the size of the processor-memory modules and the

computational and reliability requirements for each task. Since the set of flight-related application tasks used in the derivation of the above higher level models is a subset of the task set considered in [8], the size of the processor and memory units is scaled down proportionally to account for the reduced workload. It will be assumed in the following discussion that each processor-memory unit has 0.16 MIP5 (millions of instructions per second) capacity and has a 5 kiloword memory. However, the computational and reliability requirements for each task are taken directly from [8]. A summary of the tasks considered and their requirements is given in Table 5.

The criticality levels described in Table 5 indicate the degree of reliability required for each task. It can be interpreted as follows (see [7], page 5):

Criticality Level 1- A function immediately critical to

Criticality Level 2- A function that will be critical to the safty of the flight at some future time during the mission.

Criticality Level 3- A function whose loss requires a significant change in mission to avoid degradation of safty.

\*Criticality Level 4- A function whose loss imposes substantial operational penalties on air crew or ATC.

'Criticality Level 5- A function whose loss has undesirable economic consequences but no significant safty degradation or operational penalty.

The notion of criticality level is used in the SIFT design to assure even distribution of tasks and orderly degradation in reconfiguration. A less critical task may be abandoned when the amount of processor and memory resources have decreased as ÷.)

# TABLE 5Task Module Properties for Task Allocation

TASK	MIPS	MEMORY (words)	- CRITICALITY LEVEL
AFC (Active Flutter Control)	0.069	92	
AC (Altitude Control)	0.023	2075	1
AUT (Autoland)	0.055	1025	1
EC (Engin Control)	0.119	1500	
IN (Inertial System)	0.034	2250	3
VOR (VOR/DME Radio)	0.004	300 .	4
AD (Air Data)	0.001	135	4
AIDS (Aircraft Integrated O Data System)	0.002	1300	5
LE (Local Executive)	0.034	320	Ľ
GE (Global Executive)	0.001	1100	1

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نىيىنى ئىچىنىنى the result of hardware failures. A highly critical task must either be reassigned to another processor-memory module, or adequate backup systems must be activated. However, the criticality level of a task also depends on the task profile of each phase. For example, although the autoland function has criticality level 1, it is not needed during the take-off phase. Hence, autoland is not allocated during that phase. The task profiles of the flight phases that can influence the criticality level are tabulated in Table 6.

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For each phase, it will be assumed that a primary task has a higher priority than a secondary task which, in turn, has a higher priority than a backup task. Accordingly, Table 6 can now be combined with the criticality levels to establish the priority of each task in the task allocation algorithm. When the system must function with a degraded performance, lower priority tasks are discarded first. To obtain the priority ordering, tasks are first ordered in accordance with Table 6, and then ordered according to criticality levels. The resulting priority ordering for each phase is summarized in Table 7.

A task allocation algorithm can now be defined using the method suggested in [8]. Although the method may not be optimal in the sense that it may not yield the highest performability, it achieves some degree of balance in workload distribution. A flowchart representing this method is given in Figure 5. The flowchart is fully explained in [8] except for the reallocation procedure which includes the following steps.

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### TABLE 6 Task Profiles

	ý	4., Y	× 6			50
	a to o			17 - F F.		
Task						
AFC (Active Flutter Control)		P	P			
AC (Altitude Control)	-	P	P	<b>P</b> .		
AUT (Autoland).					Ρ	
EC (Engin Control)	Ρ	P	Ρ,	P	Ρ	
IN (Inertial System)	P	Ρ	Р •	• P	<b>P</b>	
VOR (VOR/DME Radio)		P	P	<b>P</b>	Ρ	
AD (Air Data)	В	B	В	В	B	
AIDS (Aircraft Integrated Data System)	S	S	S	S	S	

Key

- P: Prime
- S: Secondary
- B: Backup
- -: Not Applicable

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## TABLE 7Priority Ordering of Tasks

Takeoff: EC > IN > AIDS > AD

Climb, Descent or Cruise: AFC = AC = EC > IN > VOR> AIDS > AD

Initial Approach: AC = EC > IN > VOR > AIDS > AD

Landing: AUT = EC > IN > VOR > AIDS > AD



FIGURE 5 Task Allocation Algorithm

- \* Allocate Local Executive to every module, and allocate Global Executive to three modules.
- Allocate remaining tasks triplicated in accordance with Table 7 and beginning with high priority tasks.
- Duplication of tasks are permitted, when resources are exhausted. However, each module has to contain at least one triplicated task (other than GE or LE) to facilitate fault identification.
- Allocate the remaining tasks without replication. However, when a processor containing a non-replicated task has failed, the task is considered to have been lost. This is because simplex assignment is not capable of fault-detection. Thus, the number of missed iterations may be intolerable.

Applying the above algorithm to the cruise phase, the results of the allocation, based on the number of available processors, are given in Tables 8 - 12. In Table 8, all tasks are allocated. Hence, knowing that there are 6 processors and at least 2 busses available, it suffices to infer that all tasks are operational. When 5 processors and at least 2 busses are available, it can be determined that the AIDS system has failed (see Table 9). Similarly, "4 processors and at least 2 busses" and "3 processors and at least 2 busses" can be associated with failure of the Inertial and AIDS systems (see Tables 10-11).

When two processors and at least two busses are available, there may exist two situations. Note that in Table 11 Engin Control is not replicated. Hence, when processor 1 has failed before processor 2 and processor 3, the Engin Control may be erroneously computed, resulting in an excessive number of missed iterations. Consequently, assuming that the failure is correctly detected with some time delay, the above situation can be inter「「「「「「「」」」」

TABLE 8Distributed Assignment of Cruise Phase TasksOver Six Processor-Memory Units

		Accumulated Task MIPS					Accumulated Task Memory Per Memory Unit				ry	
	1	2	3	4	5	6	1	2	3	4	5	6
LE (Local Executive)	.034	.034	.034	.034	.034	.034	320	320	• 320	320	320	320
GE (Global Executive)	.035	.035	.035	-	-		1420	1420	1420		••••••••••••••••••••••••••••••••••••••	-
EC (Engin Control)				.153	.153	•	-			1820	1820	-
AFC (Active Flutter Control)	.104	.104				.103	1512	1512			-	412
AC (Altitude Control)	.127	.127		-	-	.126	3587	3587	•	-	-	2487
IN (Inertial System)			•069			.160		-	3670	<b>-</b>	-	4737
VOR (VOR/DME)	.131			.157	.157		3887	••••		. 2120	2120	-
AD (Air Data)		.128		.158	.158			3722		2255	2255	-
AIDS (Aircraft Inte- grated Dat: System)			.071	.160	.160				4970	3555	3555	-

	Accumulated Task MIPS					Accumulated Task Memory Per Memory Unit					
Task	1	2	3	4	5	1	2	3	4	- 5	
LE (Local Executive)	0.034	0.034	0.034	0.034	0.034	320	320	320	320	320	
(E (Global Executive)	0.035	0.035	0.035		-	1420	1420	1420		-	
EC (Engin Control)	0.154	-		0.153	-	2920		_	1820		
AFC (Active Flutter Control)		0.104	0.104		0.103		1512	1512		412	
AC (Altitude Control)	-	0.127			0.126	4	3587	••••		2487	
IN (Inertial System)			0.138		0.160			3762		4737	
VOR (VOR/DME)	0.158	0.131		0.157		3220	3887		2120	-	
AD <b>(Air Data)</b>	0.159		0.139	0.158	-	3355	1	3897	2255		
AIDS (Aircraft Inte- grated Data System)	disca	arded				disc	arded				

TABLE 9 Distributed Assignment of Cruise Phase Tasks Over Five Processor-Memory Units

	Accu	mulated Per Pro	Task N cessor	AIPS	Accumulated Task Memory Per Memory Unit				
Task	1 1	2	3	4	1	2	3	4	
LE (Local Executive)	0.034	0.034	0.034	0.034	320	320	320	320	
GE (Global Executive)	0.035	0.035	0.034		1420	1420	1420		
EC (Engin Control)	0.154			0.153	2920	······································		1820	
AFC (Active Flutter Control)		0.104	0.104			- 1512	1512		
AC (Altitude Control)		0.127	0.127			3587	3587		
VOR (VOR/DME)	0.158	0.131		0.157	3220_	3887		2120	
AD (Air Data)	0.159		-0.128	0.158	3355		3722	2255	
IN (Inertial System)	discar	đeđ			disca	rded		•	
AIDS (Aircraft Inte- grated Data System)	discar	ded			disca	rded:			

TABLE 10 Distributed Assignment of Cruise Phase Tasks Over Four Processor-Memory Units

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	Accumu Pe:	lated Tas r Process	k MIPS sor	Accum	Accumulated Task Memory Per Memory Unit			
Task	1	2	3	1 1	2	3		
LE (Local Executive)	0.034	0.034	0.034	320	320	320		
GE (Global Executive)	0.035	0.035	0.035	1420	1420	1420		
EC (Engin Control)	0.154			2920				
AFC (Active Flutter Control)		0.104	0.104		1512	1512		
AC (Altitude Control)		0.127	0.127	-	3587.	. 3587		
VOR (VOR/DME)	0.158	0.131	0.131	3220	3887	3887		
AD (A <u>ir Dat</u> a)	0.159	0.132	0.132	3355	4022	4022		
IN (Ine <del>rtial</del> System)	discard	led		discar	rded			
AIDS (Aircraft Inte- grated Data System)	discar	led		discar	cded			

TABLE 11 Distributed Assignment of Cruise Phase Tasks Over Three Processor-Memory Units

. 4

Task LE (Local Executive)	Accumulated Task MIPS Per Processor		Accumulated Task Memory Per Memory Unit		lemory
	0.034	2 0.034	1 320	2 320	
GE (Global Executive)	0.035	0.035	1420	1420	
EC (Engin Control)	0.154		2920		
AFC (Active Flutter Control)		0.104		1512	OFFE
AC (Altitude Control)		0.127		3587	POOR
'38 (V92/385)	<b>9.15</b> 3	D.131	3220	3887	OUR

TABLE 12 Distributed Assignment of Cruise Phase Tasks Over Two Processor-Memory Units

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discarded

preted as failure of the Engin Control, together with other tasks discarded in Tables 11-12. However, when processor 2 or processor 3 has failed before processor 1, the failure will be detected immediately and reconfiguration will be initiated. In this case, only the Inertial and AIDS tasks would have been lost, but not Engin Control. Accordingly, these two situations must be distinguished in the computer model (see Section 3.3.2.2). Applying the allocation algorithm to all phases, tasks lost through reconfiguration are shown in Table 13.

#### The Phased Computer Model 3.3.2.2

As indicated in the previous section, the probabilistic nature of the computer is represented by a non-homogeneous Markov process. As discussed, the state space of this Markov process is selected in accordance with (i) compliance of the task allocation algorithm with the higher level models and (ii) preservation of the Markov properties via the failure characteristics of the hardware components.

During the takeoff phase (phase 1), the computer is represented by a Markov model with a state transition graph as illustrated in Figure 6. Each state of the graph (except F) represents a specific number of fault-free resources. More precisely, state (i,j) represents a configuration consisting of i fault-free processors and j fault-free busses. State F represents any other configuration. Using Table 13, the state q of the computer at the end of phase 1 relates to the accomplishment of functional tasks during phase 1 as follows.

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No. of Processors	1	Pha 2 - 6	se <u>7</u>	8 8
n			•	
- 6				
5		AIDS		
4	Inertial	Inertial and VAIDS	AIDS	AIDS
3	Inertial	Inertial and AIDS	AIDS	Air Data and AIDS
2	Inertial	Engin Control Inertial AIDS or Inertial AIDS	Engin Control Inertial AIDS or Inertial	Engin Control Air Data AIDS or AIDS
1 5	AllTasks	All Tasks	All Tasks	All Tasks

TABLE 13 Tasks Lost Through Reconfiguration





Key: p = failure rate for each processor unit q = failure rate for each bus unit

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If q = (i,j) then  $\begin{array}{l}
\text{no degradation if} \\
n \ge i \ge 5, m \ge j \ge 2, \\
\text{Inertial System loss if} \\
4 \ge i \ge 2, m \ge j \ge 2, \\
\end{array}$ 

If q = F then all functional tasks lost.

During each of the remaining phases, the computer model is the Markov process with state transition graph shown in Figure 7. Although the underlying Markov processes are the same for these phases, a given state has different effects on level 1 behavior during different phases. For phases 2 - 6 (climb, cruises I-III and descent), the state q at the end of the phase relates to functional task accomplishment as follows:

no degradation if  $n \ge i \ge 6$ ,  $m \ge j \ge 2$ , AIDS loss if i = 5,  $m \ge j \ge 2$ , Inertial and AIDS loss if i = 3 or 4,  $m \ge j \ge 2$ , Engin Control, Inertial and AIDS loss if  $i = 2^{\circ}$ ,  $m \ge j \ge 2$ , Inertial and AIDS loss if i = 2,  $m \ge j \ge 2$ .

If q = F then all functional tasks lost.



FIGURE 7 Markov Transition Graph for Phases Other Than Takeoff

Key: p = processor failure rate
q = bus failure rate

ê .,

For the approach phase (phase 7) the state q at the end of phase 7 implies the following:

 $\begin{array}{l} \text{no degradation if} \\ n \geq i \geq 5, \ m \geq j \geq 2, \\ \text{AIDS loss if} \\ i = 3 \ \text{or} \ 4, \ m \geq j \geq 2, \\ \text{Engin Control, Inertial and AIDS loss if} \\ i = 2', \ m \geq j \geq 2, \\ \text{Inertial system loss if} \\ i = 2, \ m \geq j \geq 2, \\ \end{array}$ 

If q = F then all functional tasks lost.

Finally, for the landing phase (phase 8) the states have the following implications:

 $\begin{array}{c} \text{no degradation if} \\ n \geq i \geq 5, \ m \geq j \geq 2, \\ \text{AIDS loss if} \\ i = 4, \ m \geq j \geq 2, \\ \text{Figure Control, Air Data and AIDS loss if} \\ i = 2', \ m \geq j \geq 2, \\ \text{Air data and AIDS loss if} \\ i = 3, \ m \geq j \geq 2, \\ \text{AIDS loss if} \\ i = 2, \ m \geq j \geq 2, \\ \end{array}$ 

If q = F then all functional tasks lost.

Given the implications of level 2 states on level 1 behavior described above, the inverse  $\kappa_2^{-1}$  of the level 2 to level 1 translation  $\kappa_2$  can be specified. For this purpose, the states of the computer model can be partitioned into seven equivalence classes

defined as follows:

 $l = {F}$  $i = {(i,j) | j \ge 2} if i = 2,2',3,4',5,$  $6 = {(i,j) | i \ge 6, j \ge 2}.$ 

The above classification of states is possible because the computational capacity of the system depends only on the number of active processors, as long as at least 2 busses are available.

Table 14 presents  $\kappa_2^{-1}$  in a format similar to Table 2.  $(\kappa_1^{-1})$ , that is,  $\kappa_2^{-1}$  is expressed in terms of its component inverses  $((\xi_{ij}\kappa_2)^{-1})$  where i is the task index ( $i \le i \le 8$ ) and j is the number of the level 1 phase ( $1 \le j \le 4$ ). Column 1 gives the coordinate (i,j) under consideration, while column 2 gives the value of the coordinate. The following abbreviations are used to denote the level 1 tasks:

> AS = AIDS VO = VOR/DME AD = AIR DATA IN = INERTIAL AL = AUTOLAND AF = ACTIVE FLUTTER CONTROL EC = ENGINE CONTROL AC = ATTITUDE CONTROL.

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	COORDINATE INVERSES OF LEVEL 2 TO LEVEL 1 TRANSLATION OF POOR QUALITY Page 1 of
LEVEL 1	LEVEL 2 Tolifetody Sets
CO- IAUPI	
<u>8416 1 1</u> AS(1) 3 1	TAKEOFF     CLIND     CRUISE I     CRUISE II     CRUISE II     CRUISE II     APPROACH     LANDING       6     6     *     *     1     1     1     1
AJ11 1 1 AJ11 1 1	
A.J.(1) 1	· · · · · · · · · · · · · · · · · · ·
AN(2) J	
83(2) 1	······································
AS(3) 0 1	6 [5,6]
	(1,2,2,3,4,5)
(1) 1 1 (3) 1 1	
1 1 (4) 0 1	
13(4) 1 1 13(4) 1 1	·····································
YU(1) U I	[2,3,4,5,6] {2,2',3,4,5,6] {2,2',3,4,5,6] * * * * * ] ]
¥υ(1) 1   ∀υ(1) 1	- [- 1] (1) [- 1] [- 1
vu(1) 1 i	
VU(2) J 1	* {2,2',3,4,5,6} {2,2',3,4,5,6} *
VU(2) 1	
¥U(3) ) [	* [2,2',3,4,5,6] [2,2',3,4,5,6] [2,2',3,4,5,6] [2,2',3,4,5,6] * ]
VU(3) 1 1	• [2,2',3,4,5,6] [2,2',3,4,5,6] 1
VU(3) -1 -1 VU(3) 1 1	
VU(4) U	* {2,2',3,4,5,6} {2,2',3,4,5,6} ]
¥∪(4) 1   ¥J(4) 1  -	
AU(1) 0 1	t [2,3,4,5,6] [2,2',3,4,5,6] {2,2',3,4,5,6] * * * ] ]
AU(1) 1 1 AU(1) 1 1	
AU(1) 1	j (2,3,4,5,6) (2,2',3,4,5,6) ↓ 1 ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓
λυ(2) ) [ Δυ(2) 1	{2, 21, 3, 4, 5, 6} [2, 2 <sup>1</sup> , 3, 4, 5, 6]
NU(2) 1	
	물론을 많은 것이 물질을 다 많은 것이 물을 모르는 것이 가장한 것이다. 그는 것이 가장은 것이 가지 않는 것이 가지 않는 것이다. 이 것이 가지 않는 것이 있는 것이 있는 것이 가지 않는 것이 있는 같은 물건은 것은 물건은 것이 것이 같은 것은 것이 같은 것이 같은 것이 같은 것이다. 것이 같은 것이 같이 있다. 것이 가
 	TAREOFF I CLINE I CRUISE I I CRUISE II I CRUISE III I DESCENT I APPROACH I LANDING
Due to space following a	AS = ALDS VU = VOR/DRE AD = ALK DATA IN = INERTIAL ADDREVIATIONS are used:   ADDREVIATIONS: AL = AUTOLAND AF = ACTIVE FLUTTER CONTRCL
	EC = ENGINE CONTROL  AC = AITITUDE CONTROL

COORDINATE INVERSES OF LEVEL 2 TO LEVEL 1 TRANSLATION

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U- I					L EV TRAJECT	EL 2 ORY SETS				1
0xD1-1VAL       xD1-1VAL       xD(3)       xD(3)		TAKEOFE		CRUISE I	CRUISE II 1 {2,2',3,4,5,6} * [2,2',3,4,5,6] [2,2',3,4,5,6] 1	CRUISE III   [2,2',3,4,5,6] 1 [2,2',3,4,5,6] [2,2',3,4,5,6] [2,2',3,4,5,6]	<u>DESCENT</u> {2,2',3,4,5,6} * {2,2',3,4,5,6} * {2,2',3,4,5,6} *	APPROACH (2,2',3,4,5,6 * 1	I         LAN DING           5         •         ]           •         ]         •           •         ]         •           •         ]         •	
AD(4) U AD(4) D AD(4) 1 AD(4) 1 (4) 1 (4) 1								(4,5,6) (2,2') (4,5,6) (1,3) (2,2')	$   \begin{bmatrix}     4, 5, 6 \\     2^{1} \\     1, 2, 2^{1}, 3 \end{bmatrix} $ $   \begin{bmatrix}     1, 2, 2^{1}, 3 \\     1, 2, 3, 4, 5, 6 \end{bmatrix} $	B C d e
		[5,6] 1,2,3,4] [5,6] [5,6]	{5,6} {1,2,2',3,4} {5,6}	{5,6} * {1,2,2',3,4}					• • • • • • • • • • • • • • • • • • •	b c d
1#(2) 0 1 #(2) 1 1 #(2) 1_				(5,6) * {1,2,2',3,4}	(5,6) [1,2,2*,3,4] [5,6]					1 Å b c
10(3) 0 13(3) 1 10(3) 1 10(3) 1 10(3) 1 10(3) 1					(5,6) (1,2,2',3,4) (5,6) (5,6)	[5,6] [1,2,2',3,4] [5,6] [5,6] [5,6]	[5,6] + {1,2,2 <sup>1</sup> ,3,4] [5,6]	{3,4,5,6} * * {1,2,2'}		A b c d e
10(4) 13(4) 1 18(4) 1								[3,4,5,6] * [1,2,2']	[2,2 <sup>1</sup> ,3,4,5,6] ] 1 [2,2 <sup>1</sup> ,3,4,5,6] ]	A b c
AL(1) J AL(1) 1 AL(1) 1 AL(1) 1 AL(1) 1	2      2      2    2	3,4,5,6] 1 ,3,4,5,6] ,3,4,5,6]	[2,2 <sup>1</sup> , 3,4,5,6] 1 [2,2 <sup>1</sup> , 3,4,5,6]	{2,2 <sup>1</sup> ,3,4,5,6] * 1						A b c d
AL(2) ) AL(2) 1 AL(2) 1				(2, 2', 3, 4, 5, 6) 1	[2,2 <sup>1</sup> ,3,4,5,6] 1 [2,2 <sup>1</sup> ,3,4,5,6]					A b c
AL(3) 0 AL(3) 1 AL(3) 1 AL(3) 1 AL(3) 1 AL(3) 1					[2,2',3,4,5,6] (2,2',3,4,5,6] [2,2',3,4,5,6] [2,2',3,4,5,6]	[2,2 <sup>1</sup> ,3,4,5,6] 1 [2,2 <sup>1</sup> ,3,4,5,6] [2,2 <sup>1</sup> ,3,4,5,6] [2,2 <sup>1</sup> ,3,4,5,6]	{2,2',3,4,5,6}   1 [2,2',3,4,5,6] *	(2,2',3,4,5,6 * * 1 *		

LANDING CRULSE II CRUISE III L DESCENT APPROACH TAKEOFF L CLIMB CRUISE L Due to space considerations, the AS = AIDS VO = VOR/DME AD = AIR DATA JN = INERTIAL Lollowing abbreviations are used: | ABBREVIATIONS: AL = AUTOLAND AF = ACTIVE FLUTTER CONTROL EC = ENGINE CONTROL AC = ATTITUDE CONTROL

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Table 14 Page 2 of 4

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	OR	IGINA	PACE
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COORDINATE INVERSES OF LEVEL 2 TO LEVEL 1 TRANSLATION

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Table 14 Page 3 of W

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LEVEL 1	LEVEL 2 TRAJECTORY SETS	1
UADI-IVAL	TAKFOFF I CLINN I CRUISE I I CRUISE II I CRUISE III I DESCENT I APPROACH I LANDING	
AL(4) 1 AL(4) 1 AL(4) 1	1     1 <td>]   A ]   b ]   c</td>	]   A ]   b ]   c
AE(1) J AE(1) 1 AE(1) 1 AE(1) 1 AE(1) 1	$\begin{bmatrix} 2,3,4,5,6 \end{bmatrix} \begin{bmatrix} 2,2^{*},3,4,5,6 \end{bmatrix} \begin{bmatrix} 2,2^{*},3,4,5,6 \end{bmatrix}$ $\begin{bmatrix} 1\\ 1\\ 2,3,4,5,6 \end{bmatrix} \begin{bmatrix} 1\\ 2,2^{*},3,4,5,6 \end{bmatrix} \begin{bmatrix} 1\\ 2,2^{*},3,4,5,6 \end{bmatrix}$	]   A ]   b ]   c ]   d
λF(2) J λF(2) 1 λF(2) 1	[ * {2,2 <sup>1</sup> ,3,4,5,6] [2,2 <sup>1</sup> ,3,4,5,6] * * * * * * * * * * * * * * * * * * *	]   A ]   b ]   c
AF(J) D AF(J) 1 AF(J) 1 AF(J) 1 AF(J) 1 AF(J) 1	$ \begin{array}{c} \begin{array}{c} \begin{array}{c} \\ \\ \\ \\ \\ \\ \\ \\ \end{array} \end{array} \\ \begin{array}{c} \\ \\ \\ \\ \\ \\ \\ \end{array} \end{array} \\ \begin{array}{c} \\ \\ \\ \\ \\ \end{array} \\ \begin{array}{c} \\ \\ \\ \\ \\ \end{array} \\ \begin{array}{c} \\ \\ \\ \end{array} \\ \begin{array}{c} \\ \\ \\ \\ \end{array} \\ \begin{array}{c} \\ \\ \end{array} \\ \begin{array}{c} \\ \\ \\ \end{array} \\ \begin{array}{c} \\ \\ \end{array} \\ \begin{array}{c} \\ \\ \\ \end{array} \\ \begin{array}{c} \\ \end{array} \\ \begin{array}{c} \\ \\ \end{array} \\ \begin{array}{c} \\ \end{array} \\ \end{array} \\ \begin{array}{c} \\ \end{array} \\ \begin{array}{c} \\ \end{array} \\ \begin{array}{c} \\ \end{array} \\ \end{array} \\ \begin{array}{c} \\ \end{array} \\ \begin{array}{c} \\ \end{array} \\ \end{array} \\ \end{array} \\ \begin{array}{c} \\ \end{array} \\ \end{array} \\ \end{array} \\ \end{array} \\ \end{array} \\ \begin{array}{c} \\ \end{array} \\ $	]   A ]   b ]   c ]   d ]   e
AF(4) 0 AF(4) 1 AF(4) 1	•     • <td>]</td>	]
EC(1) U EC(1) 1 EC(1) 1 EC(1) 1 EC(1) 1	$ \begin{bmatrix} (2,3,4,5,6) & (2',3,4,5,6) & (2',3,4,5,6) \\ 1 & 1 & 1 \\ 1 & (2,3,4,5,6) & (1,2) \\ 1 & (2,3,4,5,6) & (2',3,4,5,6) & (1,2) \end{bmatrix} $	]   A ]   b ]   c ]   d
EC(2) 0 EC(2) 1 EC(2) 1	$ \begin{bmatrix} 2^{1}, 3, 4, 5, 6 \end{bmatrix} \begin{bmatrix} 2^{1}, 3, 4, 5, 6 \end{bmatrix} $	]   A ]   b ]   c
EC(3) 0 EC(3) 1 EC(3) 1 EC(3) 1 EC(3) 1	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	]   A ]   b ]   c ] d ] e
EC(4) 0 EC(4) 1 EC(4) 1	•     • <td>]   <b>)</b> ]   b ]   c</td>	]   <b>)</b> ]   b ]   c
AC(1)     0       AC(1)     1       AC(1)     1       AC(1)     1       AC(1)     1	$\begin{bmatrix} 2,3,4,5,6 \\ 2,2^{*},3,4,5,6 \\ 2,2^{*},3,4,5,6 \end{bmatrix}$	
Due to sp tolloging	TAKEOFF 1 CLIND 1 CRUISE T 1 CRUISE II 1 CRUISE III 1 DESCENT 1 APPROACH 1 LANDING pace considerations, the $AS = AIDS$ VO = VOR/DHE AD = AIR DATA IN = INERTIAL g abbreviations are used: 1 ABBREVIATIONS: AL = AUTOLAND AF = ACTIVE FLOTTER CONTROL	

			COORDINATE INVERSES OF LEVEL 2 TO LEVEL 1 TRANSLATION Page 4	14 4 of 4
$\frac{1}{100} \frac{1}{100} \frac{1}$			LEVEL 2 TRAJECTORY SETS	I NAME
VALE L	TAKEOFE	CLIND	CRUISPI CRUISE II   CRUISE III   DESCENT   APPROACH   LANDING	Ì
AC(2) J			[2,2',3,4,5,6] [2,2',3,4,5,6] * ]	A A
AC(2) = 1 = 1 AC(2) = 1 = 1			1 [2,2,3,4,5,6]	C
AC(3) 2-1			{2,2',3,4,5,6] {2,2',3,4,5,6] {2,2',3,4,5,6] {2,2',3,4,5,6] {2,2',3,4,5,6}	A b
$\begin{array}{c} A \cup \{3\} \\ A \cup \{3\} \\ A \cup \{3\} \\ \end{array}$			* [2,2',3,4,5,6] [2,2',3,4,5,6] 1 * ] * [2,2',3,4,5,6] [2,2',3,4,5,6] [2,2',3,4,5,6] 1 * ]	c
AC(3) 1 1			8,000 m •	e
			<b>* * * * * * * * * *</b>	A b
		에는 바이가 좋아하는 것을 바람이 있는 바이지 않는	• • • • • • • • • • • • • • • • • • • •	

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I TAKEOFF I CLINB I CRUISE I I CRUISE II I CRUISE TIT I DESCENT I APPROACH I LANDING	
	· · · · · · · · · · · · · · · · · · ·
Due to space considerations, the AS = AIDS YO = VOR/DME AD = AIR DATA IN = INERTIAL	2
tollowing abbreviations are used: [ ABBREVIATIONS: AL = AUTOLAND AF = ACTIVE FLUTTER CONTROL	i i i
PC = FNCTNP CONTROL AC = ATTITUDE CONTROL	

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1.00 Columns 3-10 then give a trajectory set that maps into the corresponding level 2 value. The union of all level 2 trajectory sets indicated for a given coordinate ij and value v is the preimage  $(\xi_{ij}\kappa_2)^{-1}(v)$ . For instance the level 2 trajectory set  $(\xi_{53} \kappa_2)^{-1}(1)$  is the union of all trajectory sets for which INERTIAL(3) = 1, i.e., the set

[\* \* \* \* {1,2,2',3,4} \* \* \*] U [\* \* \* {1,2,2',3,4} {5,6} \* \* \*] U [\* \* \* {5,6} {5,6} {1,2,2',3,4} \* \*] U [\* \* \* {5,6} {5,6} {5,6} {1,2,2'}].

Finally, the last column of table 14 assigns each trajectory set a one letter name. Again, capital letters denote trajectory sets associated with coordinate values of 0; lower case names are used with trajectory sets affiliated with coordinate values of 1. Sets are then referred to by these names in a later table (Table 15).

Using  $\gamma_1^{-1}$  (Table 3) and  $\kappa_2^{-1}$  (Table 14), the desired base model trajectory sets are determined. This step is described in the section that follows.

## 3.3.3 Derivation of Base Model Trajectory Sets

Given the inverse  $\gamma_1^{-1}$  of the level 1 based capability function  $\gamma_1$  (Table 3) and given the inverse  $\kappa_2^{-1}$  of the interlevel translation  $\kappa_2$  (Table 14), the inverse  $\gamma_2^{-1}$  of the level 2 based capability function is determined in a manner similar to the derivation of  $\gamma_1^{-1}$ . Moreover, since level 2 is the bottom level,  $\gamma_2^{-1} = \gamma^{-1}$ , the inverse the capability function of the total system. More precisely, if a is an accomplishment level, let  $U_1 \times V_1$ ,  $U_2 \times V_2, \ldots, U_m \times V_m$  denote the Cartesian components of the level 1 trajectory set  $\gamma_1^{-1}(a)$  (see Table 3). For a particular component  $U_k \times V_k$ ,  $U_k$  denotes the "composite part" of the trajectory set (the first eight rows that describe functional task accomplishment) and  $V_k$  denotes the "basic part" (the last row that describes WEATHER behavior). Then, as with equation (3.1.3), it follows that

$$\gamma^{-1}(a) = \gamma_2^{-1}(a) = \bigcup_{k=1}^{m} \kappa_2^{-1}(U_k) \times V_k.$$
 (3.3.1)

(Note that (3.3.1) differs from (3.1.1) in that the basic trajectories (WEATHER) must be carried down from level 1 to level 2. Also, when  $V_k$  is carried down, additional coordinates are added to match the number of phases of the level 2 model.) Each preimage  $\kappa_2^{-1}(U_k)$  is then formulated using equation (3.1.2), where in this case the coordinate indices in C are pairs (i,j); i being the i<sup>th</sup> functional task and j being the j<sup>th</sup> phase of the level 1 trajectories. Hence  $\kappa_2^{-1}(U_k) = \bigcap_{ij=1,1}^{8,4} (\xi_{ij} \kappa_2)^{-1} (\xi_{ij}(U_k))$ . (3.3.2)

The values of the intersected terms on the right are determined

using Table 14, such that each term is expressed as a union of Cartesian sets. These unions are then intersected according to equation (3.3.2), in the systematic fashion used earlier at level 1. The result is an expression of  $\kappa_2^{-1}(U_k)$  as a union of Cartesian trajectory sets. Finally, applying (3.3.1),  $\gamma^{-1}(a)$  is just the union of all the  $\kappa_2^{-1}(U_k)$  unions (k = 1,2,...,m) with the weather trajectories  $V_k$  adjoined to each Cartesian component of  $\kappa_2^{-1}(U_k)$ . These resulting sets are displayed in Table 1 . To illustrate this computation, consider the following example.

#### Example

Suppose  $a = a_0$ . Then from Table 3 (or, alternatively, the example at the end of Section 3.3.1.3),  $\gamma_1^{-1}(a_0)$  has four Cartesian componints:

U 1 =	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 * \$\$\$\$\$\$\$\$\$\$	$U_{2} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 &$	AIDS VOR/DME AIR DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL WEATHER
v <sub>3</sub> =	$\begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 &$	$U_{4} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 &$	AIDS VOR/DME AIR DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL WEATHER

Consider now the trajectory set  $U_1$ .  $\xi_{ij}(U_1)$  is the i,j<sup>th</sup> entry of  $U_1$ , and, excess for the values \* and  $\phi$  (which as argued

				LEVEL 2 DASED CAPAUILITY FUNCTION				TABLE 15 PAGE 1 OF 17
ACCOMPLISHMENT LEVEL		L EVEL FUR	2 TRAJECTCRY LEVEL 1 TR	SET NAMES A JECTORIES	<b> </b>	RESULTI LEVEL 2 TRAJI	NG CTORY SET:	5
<b>ي (ن</b> )		A A A C C A A A A A	A A A A A A A * A * A A A A	AIDS , VOR/DNF AIR DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL	TAKEOFF CLIMB CRUISE I CRUISE II CRUISE III DESCENT APPROACH LANDING	6       6       6       6       6       6       6       1       6       1       6       1       5,6		
a(V)		A A A A A A A A A	A A A A A A A A A A A A A A A A A A A A	AIDS VOR/DME AIR DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL	TAREOPP CLIMB CRUISE I CRUISE II CRUISE III DESCENT APPROACH LANDING	[ 6 6 6 6 6 6 5,6 5,6	1     1     1     1       1     1     1     1       1     1     1     1       1     1     1     1       1     1     1     1       1     1     1     1       1     1     1     1       1     1     1     1       1     1     1     1	
a[1]				AIDS VOR/DHE AIR DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL	TAKEOFP CLIMB CRUISE I CRUISE II CRUISE III CRUISE III DESCENT APPROACH LANDING	5         [5,6]         [5,6]         [5,6]         [5,6]         [4,5,6]         [4,5,6]         [4,5,6]		
a (1)				AIDS VOR/DNE AIR DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL	TAKEOPP CLIMB CRUISE I CRUISE II CRUISE III CRUISE III DESCENT APPROACH LANDING	[ 6   5,6]   (5,6]   (5,6]   (5,6]   (4,5,6]   (4,5,6]		
۹(۱)			• • • • • • • • • • • • • • • • • • •	AIDS VOR/DME AIR DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL	TA KEOPP CLIMB CRUISE I CRUISE II CRUISE III DESCENT APPROACH LANDING	[ 6   5   [5,6]   [5,6]   [5,6]   [4,5,6]   [4,5,6]		
Colu Colu Colu	inn 1: Pha imu 2: Pha inn 3: Pha inn 4: Pha	se 1 = Taked se 2 = Cruis se 3 = Cruis se 4 = Land	off/Cruise A       se b       ise c       ing       i	Names are defined in Table 14.	For each row level 1 traj the intersec named in Col	, the resulting ectory set is tion of the set umn 2.	S	

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	L	eve	L 2	BA	SE	<b>D</b>	
CA	PA	BIL	TTY	Pt	INC	TICN	

## TABLE 15 PAGE 2 OF 17

ACCOMPLISHMENT	LEVEL	2 TRAJE	CICRY	SET NANES		RESULTI	NG CROB K CROC	
	A A A A A A A A A A	• A A A A A A A		AIDS VOR/DME AIR DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL	TAKEOPF CLIMB CRUISE I CRUISE II CRUISE III CRUISE III DESCENT APPROACH LANDING	1     5       1     (5,6)       1     (5,6)       1     (5,6)       1     (5,6)       1     (5,6)       1     (5,6)       1     (5,6)       1     (5,6)       1     (5,6)       1     (5,6)       1     (5,6)		
4(1)	A A A A A A A A A A	• A A A A A A		ALDS VOE/DNE AIR DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL	TAREOPP CLIMB CRUISE I CRUISE II CRUISE III DESCENT APPROACH LANDING	<pre>[ 6 ] 5 [ {5,6} ] {5,6} [ {5,6} ] {5,6} [ {4,5,6} ] {4,5,6} [ {4,5,6}</pre>		
-1(1)	A A A Z A A A A A	н А А А А А А А А А А		AIDS VOR/DHE AIR DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL	TAKEOPP CLIMB CRUISE I CRUISE II CRUISE III DESCENT APPROACH LANDING	[ 6 ] 5 ] [5,6] ] [5,6] [ [4,5,6] [ [4,5,6]		
• <b>•</b> (1)	а а а а а а а а	* A A b * A A A		AIDS VOR/DHE AIR DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL· ENGINE CONTROL ATTITUDE CONTROL	TAREOFF CLIMB CRUISE I CRUISE II CRUISE III DESCENT APPROACH LANDING	5         (5,6)         (5,6)         (2',3,4)         (2',3,4,5,6)         (4,5,6)         (4,5,6)		

5	Column	1:	Phase	1	=	Takeoff/Cruise 1   Names are defined in   For each row, the resulting	
	Column	2:	Phase	2	Ŧ	Cruise black high trade 14. I have a level 1 trajectory set is	
	Column	3:	Phase	3	Ξ	Cruise c /	
	Column	4:	Phase	4	=	Landing and 198 and 198 and 198 and 198 and 198 named in Column 2.	

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TABLE 15 PAGE 3 CF 17

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LEVEL	LE	VEL 2 TRAJECTORY FOR LEVEL 1 TI	SET NAMES		RESULT LBVEL 2 TRAJ	ING ECTORY SET	[5	
<u>i</u> i.r		, , , , , , , , , , , , , , , , , , ,	T	I TAKFORE	r 1 5	] [ ] ]		
	<u>0</u>		I KIDS		15.61			
			1 ATR DATA	CRIITSE T	1 15.63	1 121		
	A		I TUPOTTAT		1 15-63			
	A A	- 1995 · · · · · · · · · · · · · · · · · ·	1 MUTOYAND		1 121 3 41			
이 말을 하는 것을 다 같은 것을 가 없다.				CROIDE III				
이 물건을 가지 않는 것을 많이 봐.			L EVELNE CONTROL					
	8 8 8	11. (1997) <b>A</b> . (1997) (1997) <b>A</b> . (1997) 11. (1997) <b>A</b> . (1997) (1997) <b>A</b> . (1997)	J ATTITUDE CONTROL	LANDING	L 21		-	
						. 1 1		
	<b>b</b>		AIDS	TAREOFF	5	1 [ ]		
	λ λ	λ.	1 YOR/DHE	CLINB	[5,6]	1.141		
	A	<b>.</b>	AIR DATA	CRUISE I	15,61	i iri		
	A	회사 (ji jan) (c. 20 🕯 (196)	I_ INERTIAL	CRUISE II	15,6	IXIFI		
	1 I		I AUTOLAND	CRUISE III	15.61	iioi		
	<b>A</b>	<b>.</b>	ACTIVE FLUTTER CONTROL	DESCENT	1 121.3.41	i i e i		
	<u>a</u> <u>a</u>	A A A A A A A A A A A A A A A A A A A	ENGINE CONTROL	APPROACH	[4.5.6]	i izi	1	
	Â	Â. Â	TTITUDE CONTROL	LANDI NG	4,5,6}	j i c j		
					<b>r</b>	т г т		
	<u>b</u> *	몰날 경험 전체가 편하는 것이다.	I AIDS	TAREOFF	) <b>5</b> 6			
	Ā A	<b></b>	VOR/DNE	CLIMB	[5,6]	1 1 4 1	al a par	
	λ.	역동 전 <b>X</b> 1 (1917년 8월 1917)	AIR DATA	CRUISE I	[5,6]	1 1 4 1		
a(1) I I	A	<u>d</u> *	INERTIAL	CRUISE II	(5,6)	1 X & F +	이 나는 문을 가지?	
승규야 한 것 같아요.	出版 和 自然 的复数 化石	stran 🖲 si su di 🔶 si si	AUTOLAND	CRUISE III	[5,6]	1 101		
	λ λ	λ λ	ACTIVE FLUTTER CONTROL	DESCENT	[ {2',3,4}	1 1 4 1		
	A	Α. Α.	ENGINE CONTROL	APPROACH	21	1 1 2 1		
	A A	λ λ	J ATTITUDE CONTROL	LANDING	21.	j igj		
				<b>7177029</b>		1 [ ]		
	2 · · · · · · · · · · · · · · · · · · ·		I ALUS	CTTWD	15 63		4.1.1	
	6 A	e en la calendaria de la c	I VUR/DAE		[5,0]			
이 같은 것은 것을 같이 같아.	4	에는 사망에 특히 있는 것이라. 특히 가락하는 것이 같은 것이 있는 것이라. 이 가지 않는 것이라.	I ALK URLA		[J,0]			
4.0								
: 알려 있는 것 같은 것 같아요. <u>한 것</u> 같이 있는 것 같이 없다. 것 같이 있는 것 같이 없는 것 같이 없 것 같이 없는 것 같이 않는 것 같이 없는 것 같이 않는 것 같이 않는 것 같이 않는 것 같이 없는 것 않이				CRUISE III				
철학, 출연은 귀엽 문가 된	<b>.</b>	A	ACTIVE FLUTTER CONTROL.	DESCENT	[0,0]			•
			A ATTINE CONTROL	TANDING	21			
	<u>c</u> +		AIDS	TAKEOPP	6	1 [=]		
1996년 1997년 1991년 19 1991년 1991년 1991	Ā. δ	A	VOR/DNE	CLIMB	5	1 1 # 1	•	
	λ λ	<b>A A</b>	I ATR DATA	CRUISE I	[5.6]	i i reit		
a(1) i i	λ λ	B	INERTIAL *	CRUISE II	(5.6)	izieli		
	1 - E	a da 📲 de la de 🖡 e de la	I AUTOLAND	CRUISE III	(21.3.4)	1 101	- 1 - 1	
4. : : : : : : : : : : : : : : : : : : :		A CONTRACTOR	ACTIVE FLUTTER CONTROL	DESCENT	121.3.4.5.61	1 1 2 1	é L	
지 않는 것이 좋겠다.	A A	그는 귀엽에 걸려?	-ENGINE CONTROL	APPROACH	14,5161		_	
	Â	Ā Ā	ATTITUDE CONTROL	LANDING	[4,5,6]	j Lei		
							وروب المحافظ	
- Column	$\begin{array}{ccc} 1 & \text{Phase } 1 = 1 \\ \hline \end{array}$	Takeoff/Cruise A	Names are defined in	For each row,	the resulting			
LOLUMN -	c; Phase ∠ = ( ], Dhace J = (	Lulse D	1994 <b>4 4 4 4 4 4</b> 4 <b>4</b> 4 <b>4 4</b>	Level ( traje	ULUEY SET 15			
COLUMN .	s: Phase J = C	CUISE C		the intersect	ion of the set	3		
Column <sup>1</sup>	I: Phase 4 = I	anding		named in Colu	n 2.			

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TABLE 15 PAGE 4 OP 17

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CONFLISHMENT!		LEVEL	2 TRAJECTORY	SET NAMES		RESULT			
<u>-<u>LFAE</u>F†</u>		FUR_	LEVEL 1 TR	AUCIUNIES		LEVEL Z TRAJE	CTORI S	2515	
a ( 1)				AIDS VOR/DHE AIR DATA INERTIAL AUTOLAND ACTIVE/FLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL	TAREOPP CLIMB CRUISE I CRUISE II CBUISE III DESCENT APPROACH LANDING	6 5 5,6 5,6 1 [5,6] 1 [2',3,4] 1 [2',3,4,5,6] 2 2 1			
<b>(1)</b> 				AIDS VOR/DHE AIR DATA INERTIAL AUTOLAND ACTIVE PLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL	TAKEOFF CLIND CRUISE I CRUISE II CRUISE III DESCENT APPROACH LANDING	[ 6 ] 5,6] [ (5,6] [ (5,6] [ (2',3,4] [ (4,5,6] [ (4,5,6]			
a(1)				AIDS VOR/DHE AIR DATA INEETIAL AUTOLAND ACTIVE FLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL	TAREOPP CLIMB CRUISE I CRUISE II CRUISE III DESCENT APPROACH LANDING	6 5 (5,6) (5,6) (2',3,4) 2' 2'			
a ( 1)				AIDS YOR/DME AIR DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL	TAKEOPP CLIMB CRUISE I CRUISE III CRUISE III DESCENT APPROACH LANDING	6 5,6 5,6 5,6 5,6 2, 2, 2,			
a(1)		<ul> <li>▲</li> <li>▲</li></ul>		AIDS VOR/DME AIR DATA INERTIAL AUTOLAND ACTIVE PLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL	TAREOPP CLIMB CRUISE I CRUISE II CRUISE III DESCENT APPROACH LANDING	6 5 (5,6) (2',3,4) (2',3,4,5,6) (4,5,6) (4,5,6)			
Colur Colur Colur Colur Colur	on 1: Phase 1 nn 2: Phase 2 nn 3: Phase 3 nn 4: Phase 4	= Takeof 2 = Cruise   = Cruise   = Landin	f/Cruise A   c   g	Names are defined in Table 14.	For each row, level 1 traje the intersect named in Colu	the resulting actory set is tion of the set tan 2.	S		

TABLE 15 PAGE 5 OF 17

ACC APLISHAENTI	LEVEL 2 TRAJECTORY	SET NAMES	RESULTING
<u>LEVEL1_</u>	FOR LEVEL 1 TR	A JECTORIES	LEVEL 2 TRAJECTORY SETS
u ( 1)	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	AIDS VOR/DNE AIB DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL BNGINE CONTROL ATTITUDE CONTROL	TAREOPP       6       6       6         CLIMB       6       6       6         CRUISE I       5       6       6         CRUISE II       (5,6)       7       6         CRUISE III       (2',3,4)       0       0         DESCENT       (2',3,4,5,6)       6       6         APPROACH       2'       6       6         LANDING       2'       6       6
-(1)	Image: state	AIDS- VOR/DNE AIB DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL	TAREOFF       6       7         CLINB       6       7         CRUISE I       5       7         CRUISE II       (5,6)       1         CRUISE III       (5,6)       1         DESCENT       (2',3,4)       1         APPROACH       [4,5,6]       7         LANDING       (4,5,6)       1
	d * * *   A A A B   A A A   B A   A A	ALDS VOR/DNE AIR DATA INERTIAL AUTOLAND ACTIVE FLUTTEE CONTROL ENGINE CONTROL ATTITUDE CONTROL	TAREOFF       6       6         CLINB       6       6         CRUISE I       5       6         CRUISE II       [5,6]       7         CRUISE III       [5,6]       0         DESCENT       [2',3,4]       6         LANDING       2'       6
s. 4(1)	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	AIDS VOR/DNE AIB DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL. ENGINE CONTROL ATTITUDE CONTROL	TAREOPP       6       4         CLINB       6       4         CRUISE I       5       4         CRUISE II       (5,6)       1       4         CRUISE III       (5,6)       1       4         CRUISE III       (5,6)       1       6         DBSCENT       (5,6)       1       6         APPROACH       2       1       6         LANDING       2       1       6
a ( 1)	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	AIDS VOR/DME AIR DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL	TAKEOPP       6       7         CLINB       6       7         CRUISE I       6       7         CRUISE II       5       7         CRUISE II       5       7         CRUISE II       5       7         DESCENT       [5,6]       1         APPROACH       [4,5,6]       7         LANDING       [4,5,6]       1
Column 1: Column 2: column 3: column 4:	Phase 1 = Takeoff/Cruise A/ Phase 2 = Cruise b Phase 3 = Cruise c Phase 4 = Landing	Names are defined in Table 14.	For each row, the resulting level 1 trajectory set is the intersection of the sets named in Column 2.

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TABLE 15 PAGE 6 QP 17

CUJ MPLISHSENTI LEVEL	LEVEL 2 TRAJFCTCRY SET NAMES FOR LEVEL 1 TRAJECTORIES	RESULTING
à(1)	A     b     *     AIDS       A     A     A     A     VOR/DME'       A     A     A     A     INERTIAL       A     A     A     A     INERTIAL       r     r     A     A     A       A     A     A     A     INERTIAL       r     r     A     A     INERTIAL       r     r     A     A     INTERTIAL       A     A     A     INTERTIAL       CONTROL     A     A     INTERTIAL	-TAREOFF 6 6 2 CLIMB 6 2 CRUISE I 6 2 CRUISE II 5 2 CRUISE II 5 2 CRUISE II 5 2 CRUISE II 6 2 CRUISE II 6 2 CRUISE II 6 2 CRUISE 1 6
a (1)	A     b     *     *     AIDS       A     A     A     A     VOR/DME       A     A     A     A     AIR DATA       A     A     b     *     INERTIAL       C     C     *     INERTIAL       C     C     *     AUTOLAND       A     A     A     A       A     A     A     A       A     A     A     A       A     A     A     A       A     A     A     A	TAKEOPP       6       6         CLIMB       6       6         CRUISE I       6       6         CRUISE II       6       6         CRUISE II       5       1         CRUISE III       2',3,4)       0         NTROL       DESCENT       [2',3,4,5,6]         APPROACH       [4,5,6]       6
a(1)	A     b     *     *     AIDS       A     A     A     A     VOB/ONE       A     A     B     AIR DATA       A     A     B     AIR DATA       A     A     B     INERTIAL       A     A     B     AIR DATA       A     A     A     B       A     A     A     A       A     A     A     A       A     A     A     A       A     A     A     A       A     A     A     A       A     A     A     A	TA REOPP       6       6       6         CLIMB       6       6       6         CRUISE I       6       6       6         CRUISE II       5       8       6         CRUISE III       (2*,3,4)       0       0         NTROL       DESCENT       [2*,3,4,5,6]       6         APPROACH       2*       7       7         LANDING       2*       7       7
a ( 1)	A     b     *     *     AIDS       A     A     A     VOR/DME       A     A     AIR DATA       A     A     AIR DATA	TAKEOPP       6       #         CLIMB       6       #         CRUISE I       6       #         CRUISE II       5       x       #         CRUISE III       5,6       0       0         NTROL       DESCENT       {2',3,4}       #       #         APPROACH       [4,5,6]       #       #         LANDING       [4,5,5]       L       #
a(1)	A     b     *     *     . AIDS       A     A     A     A     VOR/DNE       A     A     B     AIR DATA       A     A     B     INERTIAL       C     Z     *     INERTIAL       C     Z     *     AUTOLAND       A     A     A     A       A     A     A     A       C     Z     *     INTRUCTOR       A     A     A     A       A     A     A     A       A     A     A     A       A     A     A     A       A     A     A     A	TAKEOFP       6       ¢         CLIND       .6       ¢         CRUISE I       6       ¢         CRUISE II       5       x       ¢         CRUISE III       [5,6]       0       •         VTROL       DESCENT       [2',3,4]       ¢         LANDING       2'       ¢       •
Column Column Column Column Column 4	1: $2$ hase $1 = Takcoff/Cruise A   Names are defined is2: Phase 2 = Cruise b   Table 14.3: Phase 3 = Cruise c   14.4: Phase 4 = Landing   14.$	in   For each row, the resulting   level 1 trajectory set is   the intersection of the sets   named in Column 2.

				LEVEL 2 BASED CAPABILITY FUNCTION				TABLE 15 Page 7 op 1
COM LISHNENT		LEVEL 2 TH	RAJECTORY EL 1 TRAJ	SET NAMES ECTORIES	   	RESULTI LEVEL 2 TRAJE	NG CTORY SETS	
• <b>u</b> (1)			* ] A   B   *   A   A   A   A   A	AIDS. VOR/DHE AIR DATA INERTIAL AUTOLAND / ACTIVE FLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL	TAKEOFP CLIMB CRUISE II CRUISE II CRUISE III DESCENT APPROACH LANDING	6 6 5 (5,6) (5,6) 2 2		
a ( 1)				AIDS VOR/DME AIR DATA INERTIAL AUTOLAND ACTIVE PLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL	TAREOPP CLIMB CRUISE I CRUISE II CRUISE III DESCENT APPROACH LANDING	<b>6</b> <b>6</b> <b>6</b> <b>6</b> <b>5</b> <b>1</b> <b>5</b> <b>1</b> <b>1</b> <b>5</b> <b>1</b> <b>1</b> <b>5</b> <b>1</b> <b>1</b> <b>5</b> <b>1</b> <b>1</b> <b>5</b> <b>1</b> <b>1</b> <b>1</b> <b>1</b> <b>1</b> <b>1</b> <b>1</b> <b>1</b>		
a(1)				AIDS VOR/DHE AIR DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL	TAKEOPP CLIMB CRUISE I CRUISE II CRUISE III DESCENT APPROACH LANDING	6 6 6 6 5 (4,5,6) (4,5,6)		
		2 • 4 • 4 • • • •		ALDS VOR/DHE AIR DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL	TAKEOFF CLIMB CRUISE I CRUISE II CRUISE III DESCENT APPROACH LANDING	6 6 6 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6 1 6		
<sup>7</sup> a.( 1)		b A A A A A A A A A		AIDS VOR/DME AIR DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTBOL ENGINE CONTROL ATTITUDE CONTROL	TAREOPP CLIMB CRUISE I CRUISE II CRUISE III DESCENT APPROACH LANDING	6 6 6 5 (5,6) (4,5,6) (4,5,6)		
Colu Colu Colu Colu Colu	nn 1: Phase 1 nh 2: Phase 2 nh 3: Phase 3 nh 4: Phase 4	= Takeoff/Cr = Cruise b = Cruise c = Landing	uise A j / H	ames are defined in provident provid	For each row level 1 tra the intersec named in Col	, the resulting jectory set is tion of the sets umn 2.		

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APLISHMENT		LF	VEL 2 TH	AJECICRY	SET NAMES		RESULT.		
			FUR LEVE	L_I_TH	UIUIUNIBD	- <u>1:</u>	LEVEL Z TRAJ	CTUNI SET	<u>S</u>
	1 A	λ	đ	*	AIDS	TAREOFF	F 6		1
	<u> </u>		in i		VOR/DN E	CLTNR	5		
	i ,	A		- Â	ATR DATA	CRIITSE T	1 6		
at lt	i a	X		1	INERTIAL	CRUISE II	6	ITE	13. 14. juli
	r e	r.	A State	λ.	AUTOLAND	CRUISE III	6	1 111	
	1 A	A	Å	λ	ACTIVE FLUTTER CONTROL	DESCENT	5 S S	iiri	
	( <b>)</b>	A la	λ -	A I	ENGINE CONTROL	APPROACH	1 14.5.61	i iri	
1	LÂ	A S	<b>X</b>	<u>,</u> У, Т	ATTITUDE CONTROL	LANDING	4 [4,5,6]	i igi	
	1 A	λ	e	•	AIDS	TAKEOPF	i 6	i i e i	
	i à	٨	1	<b>A</b> 1	VOR/DEE	CLIMB	6	i iei	
	i A	۸ (	8	1 1	AIR DATA	CRUISE I	1 6	itel	
<b>x(1)</b> i	i A	λ -	<b>.</b>	λ 1	INERTTAL	CRUISE II	6	ixiei	
	1 E .	F	8	en <sup>1</sup> <b>λ</b> i su j	AUTOLAND	CRUISE III	6	1 111	
		λ.	λ.	λ Ι	ACTIVE PLUTTER CONTROL	DESCENT	6	i ei	
	A S	A	۸.	λ 1	ENGINE CONTROL	A PPROACH	4	i iri	
	L A	Å	λ	<b>.</b>	ATTITUDE CONTROL	LANDING	L [4,5,6]	J LEJ	
								. E J	
	T		an tha an tha an the second	1					
	Ι λ	A	Ð		AIDS	TAKEOFF	6	1 1 # 1	
	1 A	Å.	Å	1 <b>1</b> 1	VOR/DNE	CLINB	- <b>1</b>		
	↓ 4	A	<b>Å</b>	A I	AIR DATA	CRUISE I	6		
d(1)	1 A	Α	Ð	• •	INERTIAL	CRUISE II	1 6		
옷 집 옷 감 같 같 !	1 5	F.			AUTOLAND	CRUISE III	[21,3,4]		
		Å		t t	ACTIVE FLUTTER CONTROL	DESCENT	[2,3,4,5,6]		
	1	A A		1 I I	ATTINDE CONTROL	I APPBUACH			
		<b>A</b>			ATTIIDDE CONTROL		[41310]		
	с 1 л		<b>h</b>		ATDS	TARPOPP	T. K	1 1 2 1	
			Ť		VORIDHE	CLINE	6		
		<b>.</b>	<b>1</b>	a i	ATR DATA	CRUISE T	6		
at 1)	i i		Ъ		INERTIAL	I CRUISE II	6	TIT	
	1 5		1월 28 🐺 👘 🗄	• • i	AUTOLAND	CRUISE III	1 121.3.41		
	1 λ	٨	A	λ i	ACTIVE PLUTTER CONTROL.	DESCENT	1 (21.3.4.5.6)	i iri	100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100
	<b>i i i i</b>	A	7	A 1	ENGINE CONTROL	A PPROACH	21	izi	
	► A	λ.	λ	λ.	ATTITUDE CONTROL	LANDING	L 21	i igi	
	<b>.</b>								
	I A	٨	<u>þ</u>	•	AIDS	TAKEOFF	<b>i 6</b>	i i ri	
	1 4	A	Ā	<b>λ</b> 1	VOR/DNE	CLIMB	6	1 I KI	
l i i	1 A	۸.	8	a 1	AIR DATA	CRUISE I	1 6 -	IIFI	
a (1)	A S	A	g	•	INERTIAL	! CRUISE II	<b>1</b> 6	1 = 1 = 1	
	1 6			1	AUTOLAND	CRUISE III	1 5	1 1 0 1	
		Δ	2	. <b>X</b>	ACTIVE PLUTTER CONTROL .	DESCENT	1 [21,3,4]	1 1 4 1	
월 1988년 18 <b>1</b> 8	1 A	A	A	λ 1	ENGINE CONTROL	APPROACH	[4,5,6]	1 1 4 1	
	<b>L A</b>	A	A	A - 1	ATTITUDE CONTROL	LANDING	L [4,5,6]	J LØJ	
Colum	n 1: Pha	ase 1 = 1	Takeoff/Cr	uise A	Names are defined in	For each ron	v, the resulting	*** ***	
Colum	n 2: Pha	ase 2 = (	Cruise b	- 1 J	Table 14.	level 1 tra	jectory set is		
Jolum	in 3: Pha	1se 3 = (	Cruise c	1	물건 물건은 알려 가슴 감독을 가지?	1 the intersed	ction of the set	S	
Colum	n 4: Phi	ase $4 = 1$	Lunding	1	회사의 가격에 가장 많은 것 같은 것 같아요.	i named in Col	luen 2.		

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#### LEVEL 2 BASED CAPABILITY FUNCTION

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ICCO HELISHNEN	11	LEVEL	2 TRAJFCTCRY	SET NAMES		RESU	LTING	
1. L.V. 3L	_ <b>I</b>	FOR	LEVEL 1 TR	JECTORIES	<u> </u>	LEVEL 2_T	AJECTORY SETS	
	1 r				TI TROPR	F c	1 1 1	
		<b>A</b>		VOD / DNP				
		A X	л. п. 1. В.	ATR DATA	CRUISE T	1 6		
J 11		1	à 🖡	INERTIAL	CRUISE II	6	TTE	
•	i i z	e i		AUTOLAND	CRUISE III	1 5	1 101	
	A A	٨	л, Л	ACTIVE FLUTTER CONTROL	DESCENT	[21, 3, 4]	and the first of t	
같은 말 같아요. 그	I I A	٨	λ λ	ENGINE CONTROL	A PPROACH	21		
이가 이 가지 않는다. 1. 전화의 가격을 알려요	1 • •	A	N A -	ATTITUDE CONTROL	LANDING	L 21	J. C. C. C. J. S.	
				n an an an Araba an Araba an Araba an Arab		1		
				ITAS	1 TAKPOPP	6		
		Â	Ť.	VORZOME	I CLINB	6	1 1 6 1	
		Å.	Λ Ē	ALR DATA	CRUISE I	6		
· · · · ·		λ.	e 🔸	INERTIAL	CROISE II	1 6	i x i ¢ i	
	1 1 4	2	<b>;</b>	AUTOLAND	CRUISE III	i 5	101	
- 2012년 - 1923년	i i A	λ .	Λ Α	ACTIVE PLUTTER CONTROL	DESCENT	1 [5,6]		
김 씨가 그 날 때 옷에	1 1 1	<b>X</b>	λ λ	ENGINE CONTROL	APPROACH	1 21	11111	
	i i k	<b>N</b>	λ	ATTITUDE CONTROL	LANDING	L 21	JLLJ	
					1 1	ana ann an Arrainn an Arrainn Arrainn an Arrainn an Arrainn		
		1	a	AIDS	TAKEOPP	i 6	i i e i	
	i i x	Ā	λ. J	VOR/DNE	CLIMB	i 6	i . i • i	
		Α.	λ λ	AIR DATA	CRUISE I	1 5	1 1 4 1	9 ¥
a( 1)	i i x	R	a 🗇	INERTIAL	CRUISE II	1 6	IXIFI	3.8
	i r	E I		AUTOLAND	CRUISE III	6	1 101	<b>2</b> 5
그는 것을 가 많 것이다.	1 I A	A	A	ACTIVE FLUTTER CONTROL	DESCENT	1 [21,3,4]	11111	8Z
	1 1 1	A	N 1	ENGINE CONTROL	APPROACH	(4,5,6]	1 1 4 1	M P
	<b>↓ ↓ ↓</b>	<b>A</b>	λ λ 4	ATTITUDE CONTROL	LANDING	L {4,5,6}	I LEI	
244.15						-		PA
		A	<b>a</b>	AIDS	TAKEOPP	6		P G
	iii	Î	i i	VOR/DHE	CLINB	6	1-1-1	E E
	i i i	4	N B	AIR DATA	CRUISE I	6.	i jej :	17 15
(1)	i i X	λ	1	INERTIAL	CRUISE II	6	XXX	
	1 1 4	2		AUTOLAND	CRUISE III	1 6		
그 아님 그 아님들이 ?	1 1 4	N 1	λ Ι	ACTIVE FLUTTER CONTROL	DESCENT	1 [21,3,4]		
	1 1 A .	<b>N</b>	NG NG BUT NG BUT	ENGINE CONTROL	APPROACH	1 21		مناقون الأواكر
	1 L A	۸ ا	λ J	ATTITUDE CONTROL	LANDING	r, 51	JLZJ	
	이 같은 것이 같은 것이다.		的复数形式					
		λ	N, CES.∔CESI	ATDS	TAKEOPP	6		
	1 1 4	<b>X</b> 7	ī. i	VO B/DM E	CLIMB .'	1 . 6	11111	
	1 I A	A J	L B.	AIR DATA	CRUISE I	1 6		
a(1)	1 1 4	٨	2 1	INERTIAL .	CRUISE II	1 ; 6	TIFIC	
[] 2012 [] 2013 [] 2014 [] 2014 [] 2014 [] 2014 [] 2014 [] 2014 [] 2014 [] 2014 [] 2014 [] 2014 [] 2014 [] 2014		£	이 영국 문화 문화 문화	AUTOLAND	CRUISE III	1 6	1 101	
	1 1 1	A		ACTIVE FLUTTER CONTROL	. DESCENT	1 5		an contra a chomarta. Bhana ta ta chana
	(1~1) - A 문헌 : (1)	λ 1	N	ENGINE CONTROL	APPROACII	1 2'	1 1 4 1	
	1	A		ATTITUDE CONTROL	LANDING	L 21	J L 🗶 J	
Co Co	lumn 1: Phase	= Takeo	ff/Cruise A	Names are defined in	For each rou	, the result	ing	
Co	Luan 2: Phase 2	2 = Cruise	∍ p  .	Table 14.	level 1 traj	jectory set i	5	
20	Lunn 3: Phase 3	) = Cruise	2 C		the intersec	tion of the	sets	
Up	Luon 4: Phase 4	i = Landir	ng l		named in Col	.9 <b>0</b> 0 2.		
				الله المراجع ا الم الم محمد محمد المراجع المراج	an and and	BARRAN ANT	state in an and a star	

#### TABLE 15 PAGE 10 OF 17

LEVEL	LEVEL	. 2 TRAJECT	IORY SET NAMES TRAJECTORIES		RESUL LEVEL 2 TRA	TING JECTORY SETS	
	<u>г</u> ала	<u>e</u> *	AIDS	TAKEOPP	r   6	] [ F ]	
	1 A A	y y	VOR/DHE	CLIMB	6		•
a/1		A 9	1 ALR DATA ( 1 THERTTAT	CRUISE I	1 6		
	i e e	* *	IAUTOLAND	CRUISE III	6		
	Î A A	λ	ACTIVE FLUTTER CONTROL	DESCENT	i 6	1 1 4 1	
	A A	λ λ	ENGINE CONTROL	APPROACH	1 2'	1 I F I	
	ча <b>Х</b> арана <b>Х</b> ара	A A	J ATTITUDE CONTROL	I LANDING	L 21	JLZJ	
	r				- 1 - 1	1 C 1	
1	1 A A	λ. <u>b</u>	AIDS	TAXEOFP	6		
		λ	VOR/DNE	CLIMB	6		
	<b>Ι</b>	A A	ALR DATA	CRUISE I	6		
404		<u>,</u>		I CRUIDE II	6		
			ACTIVE FLUTTER CONTROL	DESCENT	1 6		
	1 λ · · · · · · · · · · · · · · · · · ·	A A	I ENGINE CONTROL	APPROACH	(5,6)		
	ί λ λ	λ λ	J ATTITUDE CONTROL	LANDING	<b>L</b> 4	j igj	
	••••••••••••••••				••••••••••••••••••••••••••••••••••••••	<b>T F T</b>	en di Bi
	1 4 4	<u>ک</u> ۲	AIDS	TAKEOPP	1 6	1 1 4 1	1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 -
김 모양은 감독에 가지?		λ	VOB/DHE	CLINB	6		
	1 A A	AAA	I AIR DATA	CRUISE I			
a( 1)	4 •	A A A	1 INDRULAL	I CRUISE II			
		Â	I ACTIVE FLUTTER CONTROL	1 DRSCENT	6		
	i A	X X	ENGINE CONTROL	APPROACH	(5.6)		
	L A A	λ	J ATTITUDE CONTROL	LANDING	L	i içi	
				i	••••••		
			AIDS	TAKEOPP	[5,6]	1 [ ]	
	<b>i</b> A	λ	VOR/DNE	CLINB	(5,6)		
양양 김 승규는 것이 같아.	A A	<u>۲</u>	I ATE DATA	CRUISE I	[5,6]		
a (2)		C *	I INERTIAL	CRUISE II	[5,6]		
		Χ	AUTOLAND	CRUISE III	[5,6]		
			ACTIVE FEBILER CONTROL	I IDDDOLCH			
	L A	Â	ATTITUDE CONTROL	LANDING	[21,3]	i lei	
					•		
	화장(*) 알 바이(*) 같다.	•	AIDS	TAREOPP	[5,6]	i izia	
	Ι λ Α	A A	I VOR/DME	CLIMB	[ (5,6)	1 1 4 1	
		V đ	I AIR DATA	CRUISE I	[5,6]		
a ( 2)	1 3		I ANDRILAD	I CRUISE IL	[0,0] /5 c1		
일을 말했다. 말하는 말 것		л). 1	I ACTIVE FILTTER CONTROL	I DECLENA	1 [0,0] 1 [5 K]		
	A A	а . Х. А.	I ENGINE CONTROL	APPROACH			•••
	L X X X	A A	J ATTITUDE.CONTROL	LANDING	1 [21,3,4,5,6]	JLZJ	
Column	1: Phase 1 = Tal	ceoff/Cruise	A   Names are defined in	Por each row	, the resulting		
Coluan	2: Phase 2 = Cru	iise b	1 Table 14.	level 1 traj	ectory set is	Ār produktionalis.	
Column	3: Phase 3 = Cru	uise c	일을 다 같은 것을 하는 것을 수 없어?	[ the intersec	tion of the se	ets	
Column	4: Phase $4 = Lat$	nding		named in Col	unn 2.		

TABLE 15 PAGE 11 OF 17

ACCOMPLISHMENT	 LEVE	L 2 TR)	JECICR	Y SET NAMES	1	RESULTI	[NG	
	 <u>F(</u>	<u>DR LEVE</u>	<u>1 T</u>	RAJECTORIES	ļ	<u>LEVEL 2 TRAJE</u>	CTORY SETS	
च (2)	* A A A Z A A A A A A A	* A A C A A A A A A A A	* 2 * * * * *	AIDS VOR/DMP AIR DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTBOL BNGINE CONTBOL ATTITUDE CONTROL	TAKEOFP CLIMB CRUISE I CRUISE II CRUISE III CRUISE III DESCENT APPROACH LANDING	[ [5,6] [ [5,6] [ [5,6] [ [5,6] [ [5,6] [ [5,6] [ [4,5,6] [ [2',3]		
s (2)	* A A C A A A A	* A A A A A A A	* 1 * * * * *	AIDS VOR/DNE AIR DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL RNGINE CONTROL ATTITUDE CONTROL	I TAKEOPP CLIMB CRUISE I CRUISE II CRUISE III CRUISE III DESCENT APPROACH LANDING	[ (5,6] [ (5,6] [ (5,6] [ (5,6] [ (5,6] [ (5,6] [ 3 [ (2',3,4,5,6]		
a(2)	* A A C A A A	* A B A A A A A A	• 2 • • • • •	AIDS VOR/DME AIR DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL	TAKEOPP CLINB CRUISE I CRUISE II CRUISE III DESCENT APPBOACH LANDING	[ [5,6] [ [5,6] [ [5,6] [ [5,6] [ [2',3,4] [ [2',3,4] [ [4,5,6] [ [2',3]		
a (2)		* A A A A A A A A A	* , <u>0</u> * * * * *	AIDS VOR/DME AIB DATA INERTIAL AUTOLAND ACTIVE FLUTTER CONTROL ENGINE CONTROL ATTITUDE CONTROL	TAKEOFF CLIMB CRUISE I CRUISE II CRUISE III DESCENT APPROACH LANDING	$\begin{bmatrix} (5,6] \\ (5,6] \\ (5,6] \\ (5,6] \\ (2^1,3,4] \\ (2^1,3,4,5,6] \\ (2^1,3,4,5,6] \\ (2^1,3,4,5,6] \end{bmatrix}$		

Column 1: Phase 1 =	Takeoff/Cruise &	Names are defined in	For each row, the resulting
Column 2: Phase 2 =	Cruine b	Table 14.	level 1 trajectory set is
Column 3: Phase 3 =	Cruise c		the intersection of the sets
Column 4: Phase 4 =	Landing		named in Column 2.
			a second second states and a second second
경험 방법 시 가 같은 것이 같은 물건이 가지 않는 것이 같은 것.		· 사망가 가지는 것 같은 바라 방법에 잘 같이 것 수 가지는 바람들이 같아요. 이것 ㅋㅋ	에 가슴 가슴에 가지 않는 것 같은 것이 있는 것이 가슴을 가지 않는 것이 있다. 이 가지 않는 것이 있는 것이 있다. 이 가지 않는

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TABLE 15 PAGE 12 OF 17

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$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	ACCUNELISHMENT		LEVEL	2 TRAJECT	CRY SET NAMES		RESULTING	
$ \begin{array}{ c c }                                  $	LEVEL		<u>t</u> O	H PEART	TRAJECTORIES		LEVEL 2 TRAJECTORI SETS	
(4)       A       A       A       A       A       CULTUR       (5,6)       (4)         (4)       A       A       CULTUR       (5,6)       (2)       (4)       (2)       (5,6)       (4)         (4)       A       A       A       (2)			•		1 AIDS	TAREOFF	15.61	•
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		i i a	A	λ λ	I VOR/DNE	CLINB	1 15,61 1 1 4 1	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	상태는 소문을 가지?	i λ	٨	λ <u>e</u>	ATR DATA	CRUISE 1	[5,6] [ # ]	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	a (2)	I A	۸	<u>b</u> •	INERTIAL.	CRUISE II	[5,6] [X] # ]	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		l I P	£	λ +	AUTOLAND	CRUISE III	[ [2*,3,4] ] ] 0 ]	
		1 A	λ.	• A . A.	I ACTIVE FLUTTER CONTROL	DESCENT	[2',3,4,5,6]     #	1. <b>x</b>
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		1 <b>X</b>	A	A	ENGINE CONTROL	APPROACH		
		L A	A	Α. Α	ATTITUDE CONTROL	LANDING	(3,4,5,6) J L ¢ J	
$a(2) = \begin{bmatrix} * & * & * & * & * & * & * & * & * & *$	이 같은 것 같은							
$a(2)   \begin{vmatrix} x & x & x & y \\ x & x & y \\ y \\ y \\ y \\ x & y \\ x & y \\ y \\ y \\ x & y \\ x & y \\ y \\ y \\ y \\ x & y \\ x & y \\ y$					1 AT DC			
$a(2) \begin{vmatrix} a & a & a & b & a & b & a & b & a & b & a & b & b$				1		I IANEUIT		
a(2)			1					
$a(2) = \begin{bmatrix} x & x & x & x & x & x & x & x & x & x$				a ⊻ A <b>¥</b>	I INFRITAR	CRUISE TT		
$a(2) = \begin{bmatrix} x & x & x & y & y & y & y & y & y & y &$			Ĵ	1 7	I AUTOLAND	I CRIITSP TIT		
$\begin{array}{c c c c c c c c c c c c c c c c c c c $			2	A	ACTIVE PLUTTER CONTROL	DESCENT		
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $			A	A A	I ENGINE CONTROL	APPROACH	1 [4.5.6] 1 1 6 1	
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		È A	λ	λ λ	ATTITUDE CONTROL	LANDING	L {2',3} J L # J	an a
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	방법을 확실했는데					i de la compañía de		•
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$		r i				1	r	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $						TAKEUFF		
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		I A	A.	A 8	VOR/DAE			· · · · ·
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		[]. <b>  ∧</b>	A 1		I ALR DATA	CRUISE I		
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	414)		A 2	ц. 1		CRUISE II		
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$				<b>.</b>	I ACTIVE FINTTER CORTROL			
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	2011년 1912년 4		1 <b>1</b>	1 1	I ENGINE CONTROL	I IDDBOICH		
$a(2) = \begin{bmatrix} * & * & * & * & * & * & * & * & * & *$		L A	Â	i	ATTITUDE CONTROL	LANDING	L [21,3,4,5,6]	
$a(2) \begin{bmatrix} \bullet & \bullet$						i.		
a(2)     A     A     A     YOR/ORE     CLINB     [5,6]     [e]       a(2)     A     A     g     AIR DATA     CRUISE I     [5,6]     [e]       a(2)     A     A     g     AIR DATA     CRUISE I     [5,6]     [e]       a(2)     A     A     g     AIR DATA     CRUISE II     [5,6]     [e]       a(2)     A     A     A     A     A     [e]     [f]     [f]       a(2)     A     A     A     A     [f]     [f]     [f]     [f]       a(2)     A     A     A     A     [f]     [f]     [f]     [f]       a(2)     A     A     A     A     [f]     [f]     [f]     [f]       a(2)     A     A     A     A     [f]     [f]     [f]     [f]       a(2)     A     A     A     [f]     [f]     [f]     [f]       a(2)     I     A     A		r i				!	f	
a(2)       A       A       A       A       A       A       Curve F       [5,6]       [4]         a(2)       A       A       A       A       A       CRUISE II       [5,6]       [6]       [6]         a(2)       A       A       A       A       A       CRUISE II       [5,6]       [6]       [6]         a(2)       A       A       A       A       A       A       [6]	철물 영상 전 문화 것이다.		열 문 문 문 문			I TAREOFF		
4(2)       A       A       A       A       A       A       A       A       A       A       A       A       A       A       CRUISE II       (5,6)       I	김 영화가 물건을 받았		A		I YOK/DAB			
a(2)       a       a       a       a       b       a       b       a       b       b       b       b       c	a / 2a			A 5	I THERTAL	CRUISE I		
A       A       A       A       A       CTIVE PLUTTER CONTROL       DESCENT       [2',3,4]       [2]         A       A       A       A       ENGINE CONTROL       APPROACH       2'       [2',3,4]       [2]         A       A       A       A       TTITUDE CONTROL       APPROACH       2'       [2',3,4]       [2]         A       A       A       A       ATTITUDE CONTROL       APPROACH       2'       [2',3,4]       [2]         A       A       A       A       ATTITUDE CONTROL       APPROACH       2'       [2',3,4]       [2]         A       A       A       A       ATTITUDE CONTROL       APPROACH       [3,4,5,6]       [2]         A       A       A       A       YOR/DHE       CLIMB       [5,6]       [2]       [4]         A       A       A       Q       ATR DATA       CRUISE II       [5,6]       [2]       [4]         a(2)       I       A       A       Q       INERTIAL       CRUISE II       [5,6]       [2]       [4]         a(2)       I       A       A       A       A       [2]       [2]       [2]       [2]       [2]       [2]	•14		Ê	<b>1</b>		I CRUISE II		
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$		i i		x x	I ACTIVE PLUTTER CONTROL	DESCENT		
A       A       A       ATTITUDE CONTROL       IANDING       (3,4,5,6)       IE         I       A       A       A       AIDS       TAKEOPF       (5,6)       IE         I       A       A       A       VOR/DHE       CLIMB       (5,6)       IE         I       A       A       A       QUR/DHE       CLIMB       (5,6)       IE         I       A       A       Q       AIR DATA       CRUISE II       (5,6)       IE         I       A       A       Q       INBRTIAL       CRUISE II       (5,6)       IE         I       A       A       A       ACTIVE FLUTTER CONTROL       DESCENT       (5,6)       IE         I       A       A       A       PRGINE CONTROL       APPROACH       2'       IE         I       A       A       A       PRGINE CONTROL       APPROACH       2'       IE         I       A       A       A       PRGINE CONTROL       APPROACH       2'       IE         I       A       A       A       PROACH       1'       IE       IE         Column 1:       Phase 1 = Takeoff/Cruise A         Names are defined in       Fo			1	λ λ	ENGINE CONTROL	A PPROACE		
Image: A constraint of the second	이들을 위해 이 전 전 가운 것이다. 이 전 전 기가 관계하는 것이 가지 않는 것이 하는 것이 같이 하는 것이다.	LA	Ā	A A	ATTITUDE CONTROL	LANDING	1 (3,4,5,6) 1 121	
(a)       (b)       (c)       (						İ., , , , , , , , , , , , , , , , , , ,		
A       A       A       A       A       A       Climb       [5,6]       [c]         a(2)       A       A       A       Q       ATR DATA       CRUISE II       [5,6]       [c]         a(2)       A       A       Q       ATR DATA       CRUISE II       [5,6]       [c]         a(2)       A       A       Q       ATR DATA       CRUISE II       [5,6]       [c]         a(2)       A       A       Q       INBRTIAL       CRUISE III       [5,6]       [c]         a(2)       A       A       A       A       A       [c]       [c]       [c]         a(2)       A       A       A       A       [c]       [c]       [c]       [c]         a(2)       A       A       A       A       [c]       [c]       [c]       [c]         a(2)       A       A       A       [c]       [c]       [c]       [c]       [c]         a(2)       A       A       [c]       [c]       [c]       [c]       [c]         [a]       [c]       [c]       [c]       [c]       [c]       [c]       [c]         [c]       [c]		1997년 - 1997년 1997년 - 1997년 - 1997년 1997년 - 1997년 - 1 1997년 - 1997년 -					je se standar og men en e	
a(2)       i       A       A       A       VOR/DBE       CLIMB       (5,6)       i       i         a(2)       i       A       A       Q       AIR DATA       CRUISE II       (5,6)       i       i         a(2)       i       A       A       Q       *       INBRTIAL       CRUISE II       (5,6)       i       i         a(2)       i       A       A       Q       *       INBRTIAL       CRUISE II       (5,6)       i       i         i       A       A       Q       *       INBRTIAL       CRUISE III       (5,6)       i       i       i         i       A       A       A       A       A       i <t< td=""><td>같은 것은 것이 많은 것이</td><td></td><td></td><td></td><td>ALDS</td><td>TAKEOFF</td><td>[5,6] [ [ ] ]</td><td></td></t<>	같은 것은 것이 많은 것이				ALDS	TAKEOFF	[5,6] [ [ ] ]	
a(2)       A       A       A       A       A       CRUISE I       (5,6)       I       I         a(2)       A       A       A       A       INPERTIAL       CRUISE II       (5,6)       I       I         I       A       A       A       A       INPERTIAL       CRUISE III       (5,6)       I       I         I       A       A       A       A       I       AUTOLAND       CRUISE III       (5,6)       I       I         I       A       A       A       A       A       I		<b>I I I I</b>	A	A A	VOR/DHE	CLIMB	[5,6] [ ] # ]	
a(2)       i       A       e       i       intential       cR01SE II       [5,6]       x       e         i       i       i       A       i       AUTOLAND       CR01SE III       [5,6]       [0]         i		A	A Second	A <u>e</u>	1 ALR DATA	CRUISE I	[5,6]	
A       A       A       A       ACTIVE PLUTTER CONTROL       DESCENT       [5,6]       [6]         I       A       A       A       A       DESCENT       [5,6]       [6]         I       A       A       A       A       DESCENT       [5,6]       [6]         I       A       A       A       DESCENT       [5,6]       [6]       [6]         I       A       A       A       DESCENT       [5,6]       [6]       [6]         I       A       A       A       DESCENT       [5,6]       [6]       [6]         I       A       A       A       DESCENT       [7]       [6]       [6]         I       A       A       A       DESCENTROL       APPROACH       [7]       [6]         I       A       A       A       A       Instructure       [7]       [7]       [6]         I       A       A       A       A       Instructure       [7]       [7]       [8]         Column 1:       Phase 1 = Takeoff/Cruise A   Names are defined in       For each row, the resulting       [7]       [7]       [8]       [8]         I       I       Instru	4(4)	<b>1 4</b>	<u></u>	e .				the second second
I     A     A     A     Image: Provide the second seco				а. 	I ACTIVE FURTER CONTROL			
L     A     A     A     A     A     A     A     Implies Control		ka ka an <b>P</b> alana. 1 an <b>1</b>	<b>.</b>		I PNCINE CONTROL			
Column 1: Phase 1 = Takeoff/Cruise A   Names are defined in   For each row, the resulting Column 2: Phase 2 = Cruise b   Table 14.   level 1 trajectory set is	2014년 전문 모	L A	Â	<b>1</b>	J ATTTHE CONTROL	TANDING		
Column 1: Phase 1 = Takeoff/Cruise A   Names are defined in   For each row, the resulting Column 2: Phase 2 = Cruise b .   Table 14.   level 1 trajectory set is	 		•• 	د		DANDING .	1-	
Column 1: Phase 1 = Takeoff/Cruise A   Names are defined in   For each row, the resulting Column 2: Phase 2 = Cruise b .   Table 14.   level 1 trajectory set is	ل حد مربع مربع مربع م		ور بارد که بین که مواهد بین ک			L		
n been see 2 1 Phase 2 - Cruise Discrete to Table 14. Constant of the level 1 trajectory set is	Colu	inn 1: Phas	e 1 = Tak	eoff/Cruise A	Names are defined in	For each rou	w, the resulting	
	Çolu	ing 2: Phase	e Z = Cru	ise b	.   Table 14.	level 1 tra	jectory set is	
Contract Column 3: Phase 3 = Cruise Contract I and the set of the intersection of the sets	Colu	an J: Phas	e 3 = Cru	150 C	사 <b>모</b> 에 가 많은 것 같은 것	the interse	ction of the sets	
Column 4; Pass 4 = Landing to the first of the second state of the	Colu	ion 4: Phase	e 4 = Lan	a 1 n g		i named in Co	LUEN 2.	

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#### LEVEL 2 BASED CAPABILITY FUNCTION

فعغر

ACCURELISHMEN	ī.	LEVEL	2 TRAJ	ECTORY	SET NAMES		RESULTI	NG CTODY SPINS	
<u>LIYEL</u>		<u>FUR</u>	-FEAER-	-1-104		- <u>4</u>	<u></u>	<u>C1041 - 2613</u>	
영토 이 같은 것 같은	ala an Eiricean Talain Eiricean ≢ra	김 영화 영화 영화 영화	<b>*</b>		AIDS	I TAREOFP	[2.3.4]	iri	
			*	+	VORIDNE	CLINB	[21,3,4,5,6]	ijej	
	•		• ·	• i	AIR DATA	CRUISE I	[21,3,4,5,6]	1. 1. 4. 1	
41.1)	i i b		<b>*</b>	• 1	INERTIAL	CRUISE II	1	1 - 1 - 1	
성의 김 김 승규는	i i ī	r	<ul> <li>Algorithm</li> </ul>	* 1	AUTOLAND '	CUUISE III	1	1. 公子 <b>十</b> 书 二	
	1   A		•	*	ACTIVE FLUTTER CONTROL	DESCENT	• • • • •		
열 같은 것은 사람들이 같이 없다.	1 1 A		* 1997	• 1	ENGINE CONTROL	APPROACH	1	18141	
	1 1 1		<b>*</b>	* 1	ATTITUDE CONTROL	LANDING		a cga	
방법 영상 문화 문화		이 이 가는 가슴 가슴 가슴 가슴 가슴. 사람은 것은 가슴 가슴 가슴 가슴 가슴.				i i sure			
	lr			1		TAVEOED	T (5 6)	7 7 7	
			<b>.</b>		AUD YDM B VTD2	I CITHA	1 121 7 41		
		2012년 1월 1931년 1월 19 1931년 1월 1931년 1월 1931년 1월 1931년 1월 19			ATR DATE	CRIITSE T	1 121.3.4.5.61		
방송에 관련하는 것은 것					TNPRTTAT.	I CRUISP TT			
영 영화 전 영상이					AUTOLIND	I CRUISE TIT			
	1 1 5		*		ACTIVE FLUTTER CONTROL	DESCENT		i e i	
	1 1 3	김 씨는 우리는 사람은	*	* 1	ENGINE CONTROL	APPROACH		isisi	and the state of the state of the
영양 관계 관습	i i A		•	* j	ATTITUDE CONTROL	LANDING	<b>L</b>	j Lgj	
						. <b>1</b>	•		
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			<b>*</b>	- <b>1</b>	AIDS	TAREOFF	[5,0]		
				· · ·	VUR/DRE				
	1.1.7		<ul> <li>■</li> <li>■</li> </ul>	1	AIN DAIA TURDATAT	I CRUIDE I	1 ( <b>4</b> , <b>9</b> , <b>9</b> , <b>1</b>		
a(3)	1 1 <u>9</u>		₹ 11 8 2 8 1 1 4 . <b>≟</b> 2 1 9 8 1 1 1 1 1		AUTOLAND	I CRITCE TIT			
			•	· •	ACTIVE PLUTTER CONTROL	DESCENT	i onieroni		
			•		ENGINE CONTROL	APPROACH	•	i izi.	
성 옷은 일을 수 있었다.	1 6 1	•	<b>€</b> ∎ 1973 P.	*	ATTITUDE CONTROL	LANDING	<b>Å</b>	J LEJ	
	1								
양 같은 같은 것을 가셨다.	l r			- 1 - <b>-</b> -		1	?	1 <b>[</b> ]	
김 씨는 말 것을 못했다.	1.1.*		9	8		TA SEOFP	[5,6]		
물건 것은 것은 것을 줄 줄	11.		¥.	*	VUR/DAE	i COUZER I	(5,6)		
				* 1	ALL UATA TUDDATI?	I CRUISE I	1 1212 11		
a(3)	115	ç			ANGRIAAD	I CRUISE II	1 127 3 4 5 61		
				1	ACTIVE FLUTTER CONTROL	DESCENT	1 121 . 3 . 4 . 5 . 61		
	1 1 3	김 승규는 김 승규는 것이다.	A		ENGINE CONTROL	APPROACH	1 [2".3.4.5.6]	1 2 1	
			<b>N</b>	Π. j	ATTITUDE CONTROL	LANDING	1 [21.3.4.5.6]	i e i	
							· · · · · · · · · · · · · · · · · · ·		
	이 전 수 있는 것					1			
	1 r		e de Granden. De nasilitado	1			· · · · · · · · · · · · · · · · · · ·	1 7 7	
				1	NOD (DMB)	TAKEUFF	[ [2,0]		
				<b>.</b>	ATP DATE	I CONTER T	1 15 61		
					THERTIT	I CRUISE I	1 (2) 3 (1)		
0 ( <del>~</del> 1		Ę			AUTOLAND	I CRUISE II	1 (2) 7 4 5 6		
			1	. I	ACTIVE PLUTTER CONTROL	DESCENT	1 (21.3.4.5.6)		
	À	가지 못 같은 방법자		λ, I	ENGINE CONTROL	APPROACH	1 121.3.4.5.61		
장 만나 날 것 같은	į Ļ λ			X	ATTITUDE CONTROL	LANDING	1 [21,3,4,5,6]		
ه چې چې بې دې نه دې ور بې وې وې و	. <b>L</b>	يند به ب به بن هو هو خو که به مه مه مه مه مر	ويترجع والمتحجم المراجع			.l			9- القاري بيان مارسي بياد ميك جيد ماديور من
Col	Lumn 1: P	hase $1 = Takeo$	EE/Cruis	seAl	Names are defined in	For each row	, the resulting		
Lo1	Lumn 2: P	nase 2 = Cruis	e D	1	14D16 14.	j level i traj	ectory set is		
Çol	Lumii J: P	nase J = Cruis	e C	ļ		i the intersed	tion of the set:	<b>3</b>	
L01	rumn 4: 2	uase 4 7 Landi	чy	- <b></b>	그는 옷이 잘 먹어야 했다. 신신	a named in col	UAU 4.		
						المراجع والمعالي الم	service and the service of the		

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TABLE 15 PAGE 14 OF 17

ACCOMPLISHMENT	(	LEVEL	2 TRAJECTORY	SET NAMES	<u>I</u>	RESULTI	IG	
LEVEL	L	FOR	LEVEL 1 TRA	JECTORIES		LEVEL 2 TRAJEC	TORI SETS	
					i -		• • • • • • • • •	
						r 1 15 c)	<b>T 1</b>	
				ALDS .	I IANEUIF	[ [3,0]		
			· · · · · · · · · · · · · · · · · · ·	ATR DATE		[ [3,0]   [5,6]		and a start of the
a (3)	i .i .	b	c +	INERTIAL	CRUISE II	1 121.3.41	T	
	i z	Ē	Ā + i	AUTOLAND	CRUISE III	[5,6]		
	Ι Λ	A	Λ Α Ι	ACTIVE FLUTTER CONTROL	DESCENT	[21,3,4,5,6]	i ri	
	F F A	A	A A	ENGINE CONTROL	APPROACH.	1 {21,3,4,5,6}		
	L	Α	λ.	ATTITUDE CONTROL	LANDING	L [2',3,4,5,6]	L g J	
								n an
사람은 한 것은 가락을 통 사람이 있는 것은 것은 것을 통하는 것이 있는 것이 같이 있는 것이 같이 있는 것이 같이 않는 것이 같이 같이 같이 않는 것이 같이 있는 것이 같이 있는 것이 없다. 것이 않는 것이 않는 것이 없는 한		•	*	AIDS	TAREOFF	[ [5.6]		
		•	A * i	VOR/DHE	CLIMB	1 15.61	I E I	
	•		a = i	AIR DATA	CRUISE I	(5,6)	i r i s	
۵ (3)	l   A	λ.	<u>₽</u> + 1	INERTIAL	CRUISE II	[5,6]	x   #   ···	
	l I B	4	A * 'I	AUTOLAND	CRUISE III	{2',3,4}	1 1 1	
	L A	λ.	A A I	ACTIVE FLUTTER CONTROL	DESCENT	[ [21,3,4,5,6] ]	F	
	A A	A	A	ENGINE CONTROL	APPROACH	[ [2",3,4,5,6] ]		
	- A	*		ATILIUDE CONTROL	I LANDING	- [2',3,4,3,0] -		
			*	AIDS	TAREOFF	[ [5,6]	ĨŗĨ	
		*	A *	VOR/DAE	CLIMB	[5,6]	1 5 1	
			A + 1	AIR DATA	CRUISE I	[5,6]	1 4 1	
a (3)	1 A	Å	<u>d</u> + I	INERTIAL	CRUISE II	[5,6]	X   F	
	1 P	e e e	<b>≜</b> ₹ [	AUTOLAND	CRUISE III	[5,6]		
	I A	A		ACTIVE FLUTTER CONTROL	DESCENT	1 (2 <sup>1</sup> , 3, 4)		
	LA	Â	A A J	ATTITUDE CONTROL	LANDING	L [21,3,4,5,6]	5 6 7	
			•	AIDS	TAREOFF	[5,6]	I e i	
			A + 1	VOR/DME	CLINB	1 [5,6] 1	IFI S	
	*	이 바람이 있는 것이 같이 있다.	A + 1	AIR DATA	CRUISE I	[5,6]		
a (3)	A A		<u>e</u>	INERTIAL	CRUISE II	[5,6]	X F F	
24 Minio 24 Minio 2013년 1월 24 1987년 - 1987년 1월 24일				AULULAUD	DRECENT			
	A	Ā	λ λ Ι	ENGTINE CONTROL	APPROACH			
영상 문화한 것을 받았는	ι <u>Α</u>	Ā.	A A J	ATTITUDE CONTROL	LANDING	121.3.4.5.61	LEJ	
	A A	Å	A A A	ATTITUDE CONTROL	A P P ROACH LANDING	[ 2',3,4,5,6]		
Colu Colu Colu	imn 1: Phase imn 2: Phase imn 3: Phase	e 1 = Takeo e 2 = Cruis e 3 = Cruis	ff/Cruise A   e b   e c	Names are defined in Table 14.	For each row level 1 traj the intersec	, the resulting ectory set is tion of the sets		

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TABLE 15 PAGE 15 OF 17 .

DAPLISHAENTI LEVEL		LEVI	EL 2 TI FOR LEVI	RAJECTORY EL 1 TR	SET NAMES AJECTORIES		BESULTI Level 2 Traje	NG CTÙR Y SETS
	ſ					A PROF		1 [ 1
			na set <b>a</b> ra en la seta br>En la seta en	이 아이 아름다. 이 아이 아	AIUS Non (DM)	TAKEUFF		F
물 이 가 잘 물 수 있는			•	set a set al a	I VOR/DE	CLIAD		
((4)) ((4)) ((4))			n dia ¥nanan Para tan		AIR DATA	CRUISE I		
a(4)			승규는 불 것 같	<b>.</b>	INERTIAL	CRUISE II		I X F
	E E	e T			AUTULAND	CROISE III		
	I D				ACTIVE FLUTTER CONTROL	DESCERT		
	에는 이 통망 것				ENGINE CONTROL	I APPROACH		
					ATTITUDE CONTROL	LANDING.		1 L £ J
	e	•		•	T I ATDS	I TAREOFF	F 1 [2.3.4.5.6]	
		*	*	•	I YOR /DNE	CLTMB	1	i e i
(1997년) 1월 1997년 1월 1 1월 1997년 1월 1		을 받 <b>는</b> 같은		•	1 AIR DATA	CRUISE I		6
× . U 1	•		2		I INERTTAL	CRUISE TT	•	
••••			•		I AUTOLAND	CRUTSE TTT		
	1 6		•		ACTIVE PLUTTER CONTROL	DESCENT	1 <b>4</b>	i izi
공학을 열등을 할 수 없	· · · · · · · · · · · · · · · · · · ·		*	ala di Bardina di Ala. Ngangan 🛊 di Bardina	I ENGINE CONTROL	APPROACH		1 1 2 1
	⊾	•	*		ATTITUDE CONTROL	LANDING	<b>t</b> •	
	r.						•	1997 - San
					I AIDS	I TAKEOFP	. {2,3,4,5,6}	1 1 4 1
	1 8 * 9		27년 <b>1</b> 년 년 년 년 년	1990 <b>*</b> 1999	VOB/DME .	CLIMB	1 [2,2',3,4,5,6]	
1 - Contra de <b>1</b> - Contra de Contra	1	1995 <b>*</b> 1999 -		•	AIR DATA	CRUISE I	1.	tin ti⊈stin seen suise
a(4)	11 · · · · · · ·	1996년 <b>*</b> 2017	*	<b>+</b>	INERTIAL	CRUISE II	📲 - State 🕈 Alexandria	
사람은 가슴을 다.	1 8	E .	* 1 * 1	•	I AUTOLAND	CRUISE III		1 1 <b>1 * 1</b>
	1 <u>d</u>	- 1 - <b></b>	· · · · •		ACTIVE FLUTTER CONTROL	DESCENT	•	
	1. *	*	*	말 같은 옷이 많이	ENGINE CONTROL	APPBOACH	1 - E - E - E - E - E - E - E - E - E -	
	L +	*	*	*	ATTITUDE CONTROL	LANDING		J to L ≇ J to the set
			*		T ATOS	TARFORR	[ 12.3.4.5.6]	
		•	*	•	VOR /DHR	CLTNB		
			*	*	ATR DATA	CRIITSE T	112.21 3 4.5 61	
	•		*	*	I TNERTTAL	CRUISE IT		Y Z
	1 2	e	*		I AUTOLAND	CRUISE ITT		
승규는 것은 것을 가지?	Ā	•	1 a 🛊 🖓 🖓	•	ACTIVE FLUTTER CONTROL	DESCENT		1 1 C 1
	e e	•ug1 <b>↓</b>	*	*	ENGTHE CONTROL	APPROACH		
	L		•	•	ATTITUDE CONTBOL	LANDING-		J
	<b>r</b>							сана на селото на сел 19 стата на селото на
가 같은 것이 같아요.			<b>#</b>		A1 US	TAKEOFF	[2,3,4,5,6]	
			2013 <b>분</b> 명을 하는		I VOR/DRE	I CLIND	[ {2',3,4,5,6}	E SEFERICA SALA
		•	•		AIR DATA	CRUISE I	2	
a(4)		•			JNERTIAL	CRUISE II	tta periot,¥a di sia	
이 일과 같은 것이 같다.		<b>K</b>			I AUTOLAND	CRUISE III	🕂 de la 🕈 de la c	€ 1 <b>*</b> 1
	1 4		<b>\$</b>		ACTIVE FLUTTER CONTROL	I DESCENT	1 · · · · · · · · · · · · · · · · · · ·	
물건이 관재하지 않는	1 <u>đ</u>	이 이 문제에 있다.		1993 - <b>1</b> 993 - 1993 - 1993 - 1993 - 1993 - 1993 - 1993 - 1993 - 1993 - 1993 - 1993 - 1993 - 1993 - 1993 - 1993	ENGINE CONTROL	APPBOACH	€13月1日(★13月)) 1	1 . 1 <b># 1</b>
	• • • • • • • • •	* • • • • • • •	*	*	ATTITUDE CONTROL	LANDING	• • • • • • • • • • • • • • • • • • •	kan sa
i	n 1: Phas	e 1 = Ta	keoff /Cr	uise A I	Names are defined in	Por each roy	. the resulting	انک بی دورو برنی اورو می دو دو می دود و در در در د
Colum	n 2: Phas	2 7 ¥ Cr	u'se h	"	Table 14	l level 1 tra	lectory set is	
ປ່ວໄມສ	n 3: Dhae	a = c			<b>Α. Υ. Τ. /b>	the interest	tion of the cot	a
Colum Colum	n 4. Dhae	a = 1 = 1 =	nding	이 문화 🛊		namod in Col	unn 2	•
				en station de la company	학생님 가지 않는 것을 바라 물건을 다 나라 다 나라 다 나라 나라.			

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LEVEL		FOR LEVEL	1 TRAJECTORIES	<u> </u>	LEVEL 2 TRAJI	CTORY	SETS
			* I ATDS	TARPOPP	r ( (5.6)	] [.	1
	이번 속 위험 한 것 같아요.	•	* VOR/DHE	CLIMB	15.61	1 1 2	1
	•	evti 🔹	* AIR DATA	CBUISE I	1 (5.3)	j i e	i
a(4)	Δ	•	* INERTIAL	CRUISE II	1	IXIE	i -
	E E	(清朝) 🍁 (金麗) 👘	*   AUTOLAND	CRUISE III	· i · · · ·	1	11.
	A <u>b</u>	•	*   ACTIVE PLUTTER CONTHOL	DESCENT	· • •	1 1 4	j.
같은 것은 고양이 있는 것이다.	A Ŧ	•	•   ENGINE CONTROL	APPROACH	ini • • • •	1 1 4	i
	<b>A</b>		* · ATTITUDE CONTROL	LANDING	<b>.</b>	j iz	3
						л г	<b>.</b>
			*   AIDS	TAKEOPP	[5,6]	1 1 4	1
방법에는 것은 동안에 가지요.		an an an tha an	* VOR/ENE	CLINB	[5,6]		1
이는 것은 것을 통해 주는 것은	이 특징 김 승규는 한다. 기	2013년 2017년 - 1	* I ALA DATA	CRUISE I	[5,6]	I	
4(4)	A	신 이 클라 나라는 것	T INTREAL	CRUISE II	2	IXIF	
				CRUISE III	1		l i i i i
	A		ACTIVE FLUTTER CONTROL	J DESCENT			
	4 1		+ I LOBITEURD CONTROL	I APPROACH	an ∎ an an an an ∰ an an an Ann an an Ann	1 1 4	1
	•••••	•••••	ATTINUS CONTROL	I LANDING		¢	de e
						<b>,</b> , , , , , , , , , , , , , , , , , ,	
	•	•	*   AIDS	TAREOPP	[5,6]	i si r	i i
		•	* VOR/DME	CLIMB	[5,6]	1 1 1	1
		•	*   AIR DATA	CRUISE I	[5,6]	1 1 1 6	1
a(4)	<b>A</b>	1993년 <b>후</b> 1993년	* [ INERTIAL	CRUISE II	[ [21,3,4,5,6]	IXIE	1.
	e e	*	+   AUTOLAND	CRUISE III	1 1 1	1: 1 *	1
	λ	<u>b</u>	*   ACTIVE PLUTTER CONTROL	DESCENT	• • • • •	1 1 4	1
	Δ.		I ENGINE CONTROL	APPROACH	1. Start 1.	1 1 5	I.
			AILLIUDE CONTROL	I LANDING	<b>.</b>		1
	그는 것이 같이 있는 것이 같이 않는다.		* AIDS	TAKEOFP	[5,6]	1 12	1
2. 建设现金融和公共	•		• I VOB/DNE	CLINB	1 {5,6}	1	1 - C
			* I AIR DATA .	CRUISE I	[5,6]	1 19	1
a(4)	Λ		*   INERTIAL	I CRUISE II	1 (2',3,4,5,6)	1 x 1 ¥	1
	f F		I AUTOLAND	CRUISE III	1 [2,21,3,4,5,6]	1 1.1	1
	A	C	ACTIVE FLUTTER CONTROL	I DESCENT	化化学	1 - 1 ×	$\mathbf{L} = \{1, 2, \dots, N\}$
	А — А — А — А — А — А — А — А — А — А —	1999 - <b>1</b> 999 - 1999 -	I ENGINE CONTROL     ATTITUDE CONTROL	APPROACH			]
		이 가슴 가슴 가슴이 가슴. 1999년 1월 1999년 1997년 19		1 PUDING			- -
			* AIDS	TAREOPP	[ [5,6]	] [=	1
			* I VOR/DHE	CLIMB	[5,6]	1 1 1	1 .
58.812 동안 (P. ) (* )	김홍영 김 씨는 홍수는 것		* AIB DATA	CRUISE I	1 [5,6]	5 I F	1
u(4)   1	★ 1 + 1		*   INERTIAL	CRUISE II	[ [2',3,4,5,6]	III	1
그는 말을 하는 것을 수가 있다. 물건을 하는 것을 수가 있는 것을 수가 없다. 물건을 수가 있는 것을 것을 수가 있는 것을 것을 수가 있는 것을 수가 있는 것을 것을 수가 있는 것을 것을 수가 있는 것을 것을 수가 않았다. 것을 것을 것을 것을 것을 수가 있는 것을 것을 수가 않았다. 것을 것을 것을 것을 것을 수가 있는 것을 것을 것을 것을 수가 있는 것을	S. K. S. S. K. S. S.	승규는 홍수 이 문제로	*   AUTOLAND	CRUISE III	1 [2, 21, 3, 4, 5, 6]	1 . 4 *	I.
경험 감독 물러 한 다	A	<u>d</u>	*   ACTIVE FLUTTER CONTROL	DESCENT	1 [2,2',3,4,5,6]	1 1 1 1	1
	λ.	*	ENGINE CONTROL	APPROACH	4. S. M. M. S.	1 1 #	1
	λ λ		* J ATTITUDE CONTROL	LANDING	•	LE	<b>.</b>
		• • • • • • • • • • • • • • • • • • •					
Column 1	: Phase $1 = Ta$	akeoff/Cruis	e A   Names are defined in	For each row	, the resulting		
COLUMN 2	: Puase Z = Ci	ruise D	1 JUDT6 14-	1 TeAst 1 tra	jectory set is		

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TABLE 15

DI	C 10 .	-17	~ *	4.77
E A			UF	

JAPLISHAENT		LEVEL	2 TRAJECTORY	SET NAMES	I RESULTING
<u></u>	محرك كمرعت مستعديك	<u>rok</u> -	LEVEL I_IN	<u>AUECIURIIIS</u>	
			•	AIDS	TAREOPE 1 (5,6) 1 1
		•	•	VORIDNE	CLINB   (5.6)     6
	•	an an an an Anna Anna Anna Anna Anna An		ATR DATA	CRUISE I I (5.6) I I F I
a (B)		•	• •	INERTIAL	CRUISE II   [2".3.4.5.6]   x   #
· · · · ·	i e	e	• •	AUTOLAND	I CRUISE III 1 2 1 1 * 1
	i A	A	٠ •	ACTIVE FLUTTER CONTROL	DESCENT [2,2',3,4,5,6]     #
		X X	<b>b</b> +	ENGINE CONTROL	1 APPROACH 1 12,21,3,4,5,611 1 # 1
1 <b>1</b>	Â	•	ATTITUDE CONTROL	LANDING + + J + C J	
				no selecta (general de la companya br>Na companya de la com ∎ companya de la comp	
1		e tit <b>∮</b> re as fras	🕨 dagi yanta 🌲 🖓 👘	AIDS	TAREOPP   [5,6]
	문제 문제	•	•	VOR/DNE ,	CLINB   (5,6)     K
1	1		•	I ATR DATA	[ CRUISE I   [5,6]     ¢
-4 (9) 1	A 1 A 1	이 이번 🌪 이 문제 문제	•	I INERTIAL	CRUISE II   [2", 3, 4, 5, 6]   I   CRUISE II   [2", 3, 4, 5, 6]   I   CRUISE II   [2", 3, 4, 5, 6]   I   CRUISE II   CRUISE II   [2", 3, 4, 5, 6]   I   CRUISE II   CRUISE II   [2", 3, 4, 5, 6]   I   CRUISE II   CRUISE II   [2", 3, 4, 5, 6]   I   CRUISE II   CRUISE II   CRUISE II   [2", 3, 4, 5, 6]   I   CRUISE II   CRUISE
	) E	£	•	I AUTOLAND	CRUISE III   [2', 3, 4, 5, 6]     *
	1 2	8	D	ACTIVE FLUTTER CONTROL	I DESCENT I I I I I I I I I I I I I I I I I I I
	λ	A	<u>c</u> *	ENGINE CONTROL	APPROACH [[2,21,3,4,5,6]]   # ]
1	LA	<b>.</b>		ATTITUDE CONTROL	LANDING CARDENS JACK LE JACK
				L AT DS	TARPOPP 1 (5-6) 1 6
	영화 문제 주셨는			NOR /DMP	$\begin{array}{c} 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 $
				I ATR DATE	
		a de la companya de Esta de la companya d		1 REA DALA 1 RUDDTLAT	
4641 1				1 10001100	$ \begin{array}{c} \mathbf{C} \\ \mathbf$
		승규는 물건을 만들어?			
	4	<b>.</b>		NCTIP CONTROL	
	LÂ	<b>.</b>		ATTITUDE CONTROL	
	• • • • • • • • • • •		•••••	ġġġġġġġġġġġġġġġġġġġġġġġġġġġġġġġġġġġġġ	
1		•	M. 아이 소리 ♥ 그 아이	AIDS .	TAREOFP   (5,6)     #
1		* *	Mgeloon •ngoola	VOR/DHE	CLIND   {5,6}     ¢
(1997) - Alexandria (1997)	1. *	. 그 가 아이는 것을 알고 있다.		AIR DATA	CRUISE I (5,6)     #
a (4)	1 N.		•	INERTIAL	CRUISE II   [2',3,4,5,6]   x   ¢
이 전 문화에	1. 4	<b>#</b>	• • • • •	AUTOLAND	CRUISE III   {24,3,4,5,6}     *
요즘 같은 것 같이 좋	1 4	. <b>↓</b> }	۱ <u>b</u> ۱	ACTIVE FLUTTER CONTROL	DESCENT   (21,3,4,5,6)     #
1	A 1	<b>∖</b>	<b>€</b>	ENGINE CONTROL	APPEOACH 1 (21,3,4,5,6) 1 1 # 1
	r y	( ا		ATTITUDE CONTROL	LABDING L 1 J L Z J
	r.				
요즘 안 같은 것.	고 영화 문화 문화		<b>—</b>	ALUS	TAREUFF [ [],0]   F
				ALK DATA	
æ(#)				INGRIAL	CHUISE IT [ [2", 3, 4, 3, 6] ] X [ F ]
그는 것을 가지 않는	1 8	<b>F</b>		AUTULAND	CHUISE III   [2', 3, 4, 5, 6]   *
	I A	Α.		AUTIVE FLUTTER CONTROL	UESCENT   [2", 3, 4, 5, 6]   F
	Ι λ	λ Ι	· <u>Þ</u> 1	ENGINE CONTROL	APPROACH [ [21, 3, 4, 5, 6] [ ] F ]
	4 A	λ. ,		ATTITUDE CONTROL	LANDING L 2 J L Z J
	mn 1. Pha	se 1 a Taken	f/Cruise J 1	Names are defined in	For each roy, the resulting
Colu	mn 7: Dha	$g_{2} = 2 = Cruied$	h l	Table 14.	level 1 tratectory set is
ral n	mn 3. Dhu	$z_0 = c_1 + c_2 $		a a <b>a parte de la constante de</b> La constante de la constante de	the interpretion of the cote
Colu	mn lis Blo	$a_{1} = u_{1} u_{1} b_{1}$	~~~	1997년 - 1997년 1998년 1997년 1 1997년 1997년 199 1997년 1997년 199	named in Calumn 2
COTA	mut 4.5 5.103	se a - rainri	•9.5 The second s		I HOMER TH PATIEN 24

earlier, can be ignored),  $\xi_{ij}(U_1) = 0$ . The level 2 Cartesian trajectory sets corresponding to these coordinate values are given by Table 14, e.g.,  $\xi_{11}(U_1) = 0$  says AIDS(1) = 0 which, by page 1, row 1 of the table, corresponds to the level 2 trajectory set

[666\*\*\*\*].

(There is only one Cartesian component in this case. In general these will be several, e.g., AIDS(1) = 1 yields the three components of page 1, rows 2-4).

Repeating this step for the remaining coordinate pairs (i,j) and using the names indicated in the last column of Table 14, the intersection of equation (3.3.2) is performed symbolically (as illustrated in the example of Section 3.3.1.3). Each product term of this expression is displayed in matrix form in the second column of Table 15; in this case there happens to be only one product term, which appears on page 1, row 1, column 2. The matrix arrangement of the names resolves their ambiguities, i.e., the A that appears as entry (i,j) names a Cartesian component that maps into  $\xi_{ij}(U_1)$ . Column 3 of Table 3 gives the resulting intersection of level 2 Cartesian sets named by entries in the matrix, along with the weather trajectories V1 that are carried down from level 1. (Note that the matrix representation in column 3 has a different orientation, due to space limitations.) Thus, for the case in point, the computation yields the trajectory set

	1	•	
TAKEOFF	[ 6 ]		¢]
CLIMB	6		¢
CRUISE I	6		¢
CRUISE II	6		¢
CRUISE III	6	×	0
DESCENT	6		¢
APPROACH	[5,6]		¢
LANDING	{5,6}		¢
	L		فسم سيا

These computations are then repeated for  $U_2$ ,  $U_3$ , and  $U_4$ . (Note that, unlike Table 3, computations that result in null sets are omitted from the tabluation.) Carrying out these computations, we find that there is only one other distinct Cartesian component associated with  $a_0$  (displayed in Table 15, page 1, row 2, column 3) and hence 「大ない」で、「大なな

	TAKEOFF CLIMB CRUISE I	6 6 6		8881	
	CRUISE III	6	×	0	••••••
	DESCENT	6		¢	
	APPROACH	{5,6}		¢	
	LANDING	{5,6}		[¢]	
				e Dina National National	
	TAKEOFF	6		¢	
	CLIMB	6		¢	
	CRUISE I	6		¢	
	CRUISE II	6		¢	
J	CRUISE III	6	×	11	1.1
	DESCENT	6		¢	
	APPROACH	{5,6}		¢	<u>ц</u>
	LANDING	{5,6}	میں کا کہ ایک ہوئی ہے۔ 1997ء - 1995ء کے مطابق میں ا	¢	

This concludes the example.

 $\gamma^{-1}(a_{0}) =$ 

On examining Table 3, one can observe that the remaining levels (a<sub>1</sub>,a<sub>2</sub>,a<sub>3</sub>,a<sub>4</sub>) involve more complex trajectory sets that are more difficult to determine. This is something we have observed before in earlier experiments, namely, that the base model trajectory set associated with the "most successful" level of performance tends to be "quite" Cartesian (i.e.,

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has few Cartesian components in its decomposition), while those of lower levels do not. Indeed, the level an trajectory set computed in the above example is purely Cartesian since the two components produced by the computational procedure differ only in the value of the phase 5 weather variable. Hence, relative to accomplishment level a0, the phases of the base model are independent (see Section 3.1.3, corollary to Theorem 5). This says in turn that if level  $a_0$  were taken to be "success" and the remaining levels were regarded as "failure," the resulting capability function would be structurebased (see Section 3.1.4, Theorem 6). In other words, the evaluation of SIFT could have been based on more conventional reliability models if "top performance" were the only concern. However, an examination of Table 15 reveals that the trajectory sets  $\gamma^{-1}$  (a) for levels  $a_1, a_2, a_3$  and  $a_4$  are "far" from being Cartesian and, accordingly, there exist interphase dependencies relative to these lower levels of accomplishment. It is at these lower levels, then, that the full generality of our evaluation techniques must be brought into play.

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## 3.3.4 Derivation of Transition Probabilities

Given the transition graphs of Figure 3 and Figure 4, there is enough information to determine the initial to final state transition matrix P(k), for each phase k (k=1,2,...,8). There are several standard techniques for obtaining the initial to final state matrices (see [10], for example). However, for this particular SIFT model, these matrices can be obtained more easily using combinational probability methods (see Section 3.2.2). This is due to the assumption that each unit fails independently with a constant failure rate.

For the first phase, the initial to final state transition matrix is a nm-(n+m)+2 by nm-(n+m)+2 matrix

$$P(1) = [p_{m} [(i,j), (i',j')]]$$

where

nm-(n+m)+2 = the number of states of the phase 1 model (see Figure 6)

and

 $p_{T_1}[(i,j),(i',j')] =$ the probability that the phase one model is in state (i',j') at time  $t_1 = t_0 + T_1$ given that the phase one model is in state (i,j) at time  $t_0$ 

> = Prob[i' processor-memory units remain at time t<sub>1</sub> | i processor-memory units are available at time t<sub>0</sub>] • Prob[j' busses remain at time t<sub>1</sub> | j busses are available at time t<sub>0</sub>]

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$$\begin{cases} \binom{i}{i} e^{-i'pt} (1-e^{-pt})^{i-i'} \cdot \binom{j}{j'} e^{-j'qt} (1-e^{-qt})^{j-j} \\ if 2 \leq i' \leq i \leq n \text{ and } 2 \leq j' \leq j \leq m; \\ 0 \text{ otherwise.} \end{cases}$$

Finally, the probability of being in state F at time  $t_1$  given that the phase 1 model is in state (i,j) at time  $t_0$  can be expressed as

 $[j],F] = 1 - \sum_{j'=2}^{j} \sum_{i'=2}^{p} p_{T_{1}}[(i,j),(i',j')].$ 

The initial to final state transition matrix for the second phase is an nm-n+1 by nm-n+1 matrix

$$P(2) = p_{T_2}[(i,j), (i', j')]$$

where

PT2

nm-n+1 = the number of states of the secondphase model (see Figure 7)  $T_2 = t_2 - t_1 = the duration of phase 2$  $P_{T_{2}}[(i,j),(i',j')] = \begin{cases} \binom{i}{i'}e^{-i'pT_{2}}(1-e^{-pT_{2}})^{i-i'} \cdot \binom{j}{j'}e^{-j'qT_{2}}(1-e^{-qT_{2}})^{j-j'} \\ if \ 3 \le i' \le i \le n \ and \ 2 \le j' \le j \le m, \\ 0 \ if \ 3 \le i < i' \le n \ or \ 2 \le j < j' \le m. \end{cases}$ 

When 2 processors and j' busses are available at the end of phase 2, two states (2, j') and (2', j') are created to distinguish two possible configurations. Corresponding with these two states, the transition probabilities are expressed as

$$P_{T_{2}}[(i,j),(2,j')] = \begin{cases} \left(j, \right)e^{-j'qT_{2}}(1-e^{-qT_{2}})^{j-j'} \cdot 2\left(j, \right)(1-e^{-pT_{2}})^{i-2}e^{-2pT_{2}} \\ if_{3} \leq i \leq n \text{ and } 2 \leq j' \leq j \leq m, \\ \left(j, \right)e^{-j'qT_{2}}(1-e^{-qT_{2}})^{j-j'} \cdot e^{-2pT_{2}} \\ if_{1} = 2 \text{ and } 2 \leq j' \leq j \leq m, \\ 0 \text{ otherwise,} \end{cases}$$

$$P_{T_{2}}[(i,j),(2',j')] = \begin{cases} \left(j, \right)e^{-j'qT_{2}}(1-e^{-qT_{2}})^{j-j'} \cdot \left(j, \right)(1-e^{-pT_{2}})^{i-2}e^{-2pT_{2}} \\ if_{3} \leq i \leq n \text{ and } 2 \leq j' \leq j \leq m, \\ 0 \text{ otherwise,} \end{cases}$$
and
$$P_{T_{2}}[(i',j),(2',j')] = 0 \text{ for } 2 \leq j' \leq j \leq m. \end{cases}$$

Furthermore,

$$\begin{pmatrix} j \\ j \end{pmatrix} e^{-j' q T_2} (1 - e^{-q T_2})^{j-j'} \cdot e^{-2p T_2}$$

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 $P_{T_2}[(2',j), (2',j')] = { if <math>2 \le j' \le j \le m$ 

0 otherwise.

Finally,

$$P_{T_{2}}[(i,j),F] = 1 - \sum_{j'=2}^{j} \sum_{i'=2}^{i} P_{T_{2}}[(i,j),(i',j')] - \sum_{j'=2}^{j} P_{T_{2}}[(i,j),(2',j')]$$

Since the remaining phases have the same transition graph as the second phase, the corresponding initial to final phase transition matrices can be represented as nm-n+1 by nm-n+1 matrices

 $P(k) = [p_{T_k}[(i,j),(i',j')]]$ 

where for each  $k = 3, 4, ..., 8 T_k$  is the duration of the kth phase and  $p_m$  [(i,j),(i',j')] is defined as above with T<sub>2</sub> replaced by T<sub>k</sub>.

Since the underlying Markov models differ for different phases, it is also necessary to specify the interphase transition matrices (see [3], Section 3.4.3). Generally, the interphase transition matrix H(k) is defined to be an n<sub>k</sub> by n<sub>k+1</sub> matrix

$$H(k) = [h_{ij}]$$

where  $n_k$  and  $n_{k+1}$  are the number of states for the k<sup>th</sup> and the k+1<sup>th</sup> phase models and

h = probability that the
state of the phase k+1
model is j (at time
t<sub>k</sub>) given that the state
of the phase k model is
i (at time t<sub>k</sub>).
For the phase models described above, the phase 1 model has  $n_1 = nm - (n+m) + 2$  states, the phase 2 model has  $n_2 = 1$ nm - n + 1 states and the interphase transition matrix H(1) is the following  $n_1$  by  $n_2$  matrix.



The above matrix is interpreted as follows. When the phase 1 model is in the state (i,j) such that  $n \ge i \ge 2$  and  $m \ge j \ge 2$  at the end of phase 1, the computer reconfigures with probability 1 to state (i,j) of the phase 2 model. For the second phase, the interphase transition matrix H(2) is represented by a  $n_2$  by  $n_3$  matrix ( $n_2 = n_3 = nm-n+1$ ).



As in the previous case, when the phase 2 model—is in state (i,j),  $n \ge i \ge 2$ ,  $m \ge j \ge 2$ , at the end of phase 2, the computer is assumed to have reconfigured into state (i,j) with probability 1. However, when the computer is in state (2',j)  $m \ge j \ge 2$  at the end of phase 2, that is, the Engin Control has failed due to error latency, the computer is assumed to be capable of detecting this failure and reconfigures to state (2,j) of phase 3.

Applying the same argument to the remaining phases, the interphase transition matrices H(k), k = 3,4,5,6,7 are the same as H(2).

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# 3.3.5 Performability Results

Having derived the trajectory sets associated with each accomplishment level in {a<sub>0</sub>,a<sub>1</sub>,...,a<sub>4</sub>} (Section 3.3.3; Table 15) and the transition matrices of the computer model (Section 3.3.4), evaluation of a sepcific system requires designation of values for the following parameters of SHIFT and its environment:

### COMPUTER (SIFT)

- Cl) Processor failure rate,
- C2) Bus failure rate,
- C3) Initial state distribution (i.e., availability of computer resources at takeoff).

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#### ENVIRONMENT

- El) Flight duration and phase durations,
- E2) Probability of Category III weather at destination airport.

Evaluations were performed for a number of specific systems determined by the following choices of parameter values.

- Cl) As in [8], the processor failure rate for each system is taken to be  $10^{-4}$  failures per hour.
- C2) As in [8], the bus failure rate for each system is taken to be 10<sup>-5</sup> failures per hour.
- C3) Two types of initial state distributions are considered. The first type is "deterministic" in the sense that one computer state has probability 1 of being the initial state (the remaining states having probability 0). If (i,j) is the state having probability 1 (recall that i is the number of faultfree processors; j is the number of fault-free busses), this distribution is denoted

# Det(i,j).

The second type of initial state distribution considered is truly probabilistic where one of two specific distributions are assumed. These are d and I, and I, and are given by Table 16.

	and the second					
State	Distril	Distribution				
(i,j)	I I	I <sub>2</sub>				
(6,6)	.64	.31,				
(6,5)	.128	.081				
(6,4)	.032	.009				
(5,6)	.16	.09				
(5,5)	.032	.009				
(5,4)	.008	.001				
Others	0	0				

# TABLE 16

# Initial State Probabilities

E1) Two filght missions are considered, a 6 hour and 25 minute flight from London to New York (JFK Airport) and a 10 hour flight from Tel Aviv to New York. The assumed phase durations associated with each flight are given in Table 17.

	Flight			
Phase	London-New York	Tel Aviv-New York		
Takeoff Climb Cruise I Cruise II Cruise III Descent Approach Landing	1 minute 15 minutes 25 minutes 5 hours 25 minutes 15 minutes 3 minutes 1 minute	1 minute 15 minutes 25 minutes 8 hours 35 minutes 25 minutes 15 minutes 3 minutes 1 minute		
Total Duration	6 hours 25 minutes	10 hours		

# TABLE 17

Phase Durations

E2) The probability of Category III weather at JFK is taken to be .011 (see [11], p.173).

For the fixed values of Cl, C2, and E2 indicated above and for choices of C3 and E1 as indicated in Table 18, 14 specific systems were evaluated (denoted  $S_1, S_2, \ldots, S_{14}$ ). For each system  $S_i$ , the resulting performability  $p_{S_i}$  is also presented in Table 18, where the entry corresponding to system  $S_i$  and accomplishment level  $a_j$  is the probability  $p_{S_i}(a_j)$ .

- To summarize the calculation of p<sub>S</sub> (a<sub>j</sub>):
- 1) The base model trajectory set  $\bar{y}_{a_j} = \gamma_{S_i}^{-1}(a_j)$ is expressed as a union of  $\bar{y}_{a_j}^{-1}$  ( $a_j$ ) Cartesian trajectory sets (see Table 15; these sets are common to each of the 14 specific systems).
- 2) The initial state distribution of S, determines the initial state vector I(0). The flight of S, with its associated phase durations, determines the specific nature of the transition matrices P(1), ..., P(8) and H(1),...,H(7) derived in Section 3.3.4.
- 3) For each Cartesian component V of  $U_a$ , V is represented by the characteristic matrices G(1),...,G(7) and F(8) (see [3], pp. 59-60) and Pr[V] is computed by the formula

$$Pr[V] = I(0) \begin{pmatrix} n \\ m = 1 \end{pmatrix} P(m)G(m)H(m) P(8)F(8).$$

(See [3], p.68, Theorem 3.)

4) The performability of S<sub>i</sub> relative to level a is the sum, over all V in U<sub>a</sub> of the Pr[V], i.e.,

$$\underline{P}_{S_{i}}(a_{j}) = \sum_{V \leq U_{a_{j}}} Pr[V]$$

Step 2) of the procedure outlined above was aided by METAPHOR wherein the DEDFAIL transition matrix generator function was employed to obtain the intraphase transition matrices P(m). The interphase transition matrices H(m) entered via the GIVEN command. In step 3), the matrices G(m) Key:

 $[\cdot]_{(a,b)} \in \mathcal{A}_{a}$ 

	Economic	Operational	Change in	
	Penalties	Penalties	Mission Profile	Fatalities
		금요한 것이 있다. 동네는 것 같은 것이 있다.		
a	No	No	No	NO
a,	Yes	No	No '	No
a	Maybe	Yes	No	No
az	Maybe	Maybe	Maybe	No
a	Maybe	Maybe	Maybe	Yes

	System	C3	El		Accomplishment Level			
	Distribution	rlight	a <sub>0</sub>	aı	a2	a <sub>3</sub>	a <sub>4</sub>	
	s <sub>l</sub>	Det(6,6)	Lon-NY	9,96×10 <sup>-1</sup>	3.80×10 <sup>-3</sup>	3.78×10 <sup>-12</sup>	6.02×10 <sup>-6</sup>	1.95×10 <sup>-12</sup>
	\$2	Det(6,5)	Lon-NY	9.96×10 <sup>-1</sup>	3.80×10 <sup>-3</sup>	3.79×10 <sup>-12</sup>	6.02×10 <sup>-6</sup>	1.95×10 <sup>-12</sup>
	S <sub>3</sub>	Det(6,4)	Lon-NY	9.96×10 <sup>-1</sup>	3.80×10 <sup>-3</sup>	1.33.10-10	6.05×10 <sup>-6</sup>	2.97×10 <sup>-12</sup>
	s <sub>4</sub>	Det(5,6)	Lon-NY	0	9.97×10 <sup>-1</sup>	1.03×10 <sup>-9</sup>	3.17×10 <sup>-3</sup>	1.55×10 <sup>-9</sup>
	s <sub>5</sub>	Det(5,5)	Lon-NY	0	9.97×10 <sup>-1</sup>	1.03×10 <sup>-9</sup>	3.17×10 <sup>-3</sup>	1.55×10 <sup>-9</sup>
	, s <sub>6</sub>	Det(5,4)	Lon-NY	О	9.97×10 <sup>-1</sup>	1.16×10 <sup>-9</sup>	3.17×10 <sup>-3</sup>	1.55×10 <sup>-9</sup>
	s <sub>7</sub>	Det(6,6)	TA-NY	9.94×10 <sup>-1</sup>	6.03×10 <sup>-3</sup>	6.07×10 <sup>-12</sup>	1.52×10 <sup>-5</sup>	1.30×10 <sup>-11</sup>

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TABLE 18

Performability Results

System	C3	El Flight	Accomplishment Level				
	Distribution		aŋ	al	a <sub>2</sub>	a3	a <sub>4</sub>
S8	Det(6,5)	та-Nұ	9.94×10 <sup>-1</sup>	6.03×10 <sup>-3</sup>	6.12×10 <sup>-12</sup>	1.52×10 <sup>-5</sup>	1.30×10 <sup>-11</sup>
S <sub>9</sub>	Det(6,4)	та-Nұ	9.94×10 <sup>-1</sup>	6.03×10 <sup>-3</sup>	2.09×10 <sup>-10</sup>	1.53×10 <sup>-5</sup>	1.71×10 <sup>-11</sup>
s <sub>l0</sub>	Det (5,6)	TA-NY	0	9.95×10 <sup>-1</sup>	1.03×10 <sup>-9</sup>	5.03×10 <sup>-3</sup>	7.15×10 <sup>-9</sup>
s <sub>11</sub>	Det(5,5)	TA-NY	0	9.95×10 <sup>-1</sup>	1-03×10 <sup>-9</sup>	5.03×10 <sup>-3</sup>	-7.15×10-9
s <sub>12</sub> .	Det(5,4)	TA-NY	. 0	9.95×10 <sup>-1</sup>	1.23×10 <sup>-9</sup>	5.03×10 <sup>-3</sup>	7.15×10 <sup>-9</sup>
s <sub>13</sub>		TA-NY	7.95×10 <sup>-1</sup>	2.04×10 <sup>-1</sup>	2.18×10 <sup>-10</sup>	1.02×10 <sup>-3</sup>	1.44×10 <sup>-9</sup>
s <sub>14</sub>	I <sub>2</sub>	TA-NY	8.95×10 <sup>-1</sup>	1.05×10 <sup>-1</sup>	1.10×10 <sup>-10</sup>	5.17×10 <sup>-4</sup>	7.26×10 <sup>-10</sup>
						•	

TABLE 18 - Continued

Performability Results

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and F(8) were likewise entered via the GIVEN command. The calculations of step 3) and step 4) were executed by METAPHOR programs.

We make no attempt at this time to interpret the performability results of Table 18. The intent of this evaluation exercise was to further establish the practicality of performability evaluation as it applies to aircraft computing systems, and we believe this has been achieved by the effort reported herein. However, having developed this model hierarchy, we plan to obtain further evaluation data by choosing other values of parameters C1-C3 and E1-E2. This data, along with the performability results of Table 18, will then be examined for possible implications regarding the design and use of the SIFT computer.

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